VRIL COMPENDIUM

VOLUME 1

WHITE-RAY CONDUCTORS

VASSILATOS

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ÆTHERFORCE

VOLUME 1

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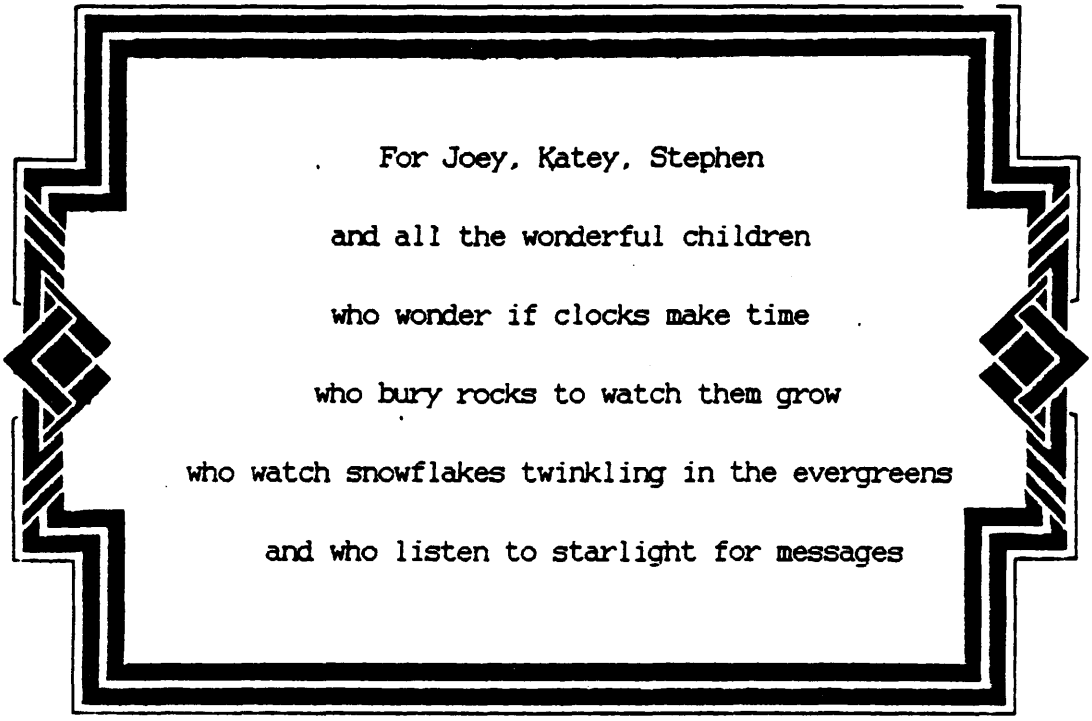
For Joey, Katey, Stephen
and all the wonderful children
who wonder if clocks make time
who bury rocks to watch them grow
who watch snowflakes twinkling in the evergreens
and who listen to starlight for messages

ÆTHERFORCE

SECTION

1

COMMENTARY

MANY THANKS TO MY COLLEAGUES
SEEKERS OF TRUTH

For countless hours of telephone conversations,
conferences, references, book loans and tape loans,
personal concerns and generous encouragements,
cherished friendships, shared adorations, precious dialogues,
secret treasures and endless visions.

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To My Dear Wife
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For her generous encouragement and genuine patience
With Great Love

TO ALL THE LONE FORGOTTEN DREAMERS
VISIONARIES
OF PAST, PRESENT, AND FUTURE

Whose Undaunted Hearts
Braved The World's Derision
And Rejections Most Cruel

Who Surrendered To Divine Revelations
Receiving The Glories Of Greater and Deeper Vision

Whose Names Remain Indelibly Written
In The Eternal Documents

By Whose Valiant Desires
And Great Agonies of Love

THE DEEP DREAMS OF VRIL MATERIALIZE

ORIGINS OF THE TERM VRIL

The name "woivre" suggests waverings and weavings and is the ancient European reference to Vril energies. Vril is the thready, living, glowing, generative energy which projects experiential space and matter. Vril is found strongly densified in the ground. Vril permeates experiential space. Vril distribution is ordained. Vril threads, channels, and causeways flood and intermingle freely. Human artifice uses special material configurations to gain Vril contact. Vril gives viscero-eidetic experience. Vril is the living generator of the experiential universe.

CELT. Virol Viria: arm, bracelet, woven
OE. wabern: to waver
ON. vafra: to hover about
veifa: to wave
OE. waefre: restless, waver
wefen: to weave
ME. Virl Virole Virell Verelle Ferrule
Weven: to move to and fro
OF. Viriola
F. Vrille: tendril, vine
Viril: potent, enlivening

Vril does not have a singular appearance. Vril is all eidetic content and vision, experience, and consciousness. Vril filamentary presence is the experiential axis. Vril filamentary presence is the conscious anchor and ground. Vril threads provide the conscious firmaments. Vril is the reference structure of the experiential universe. The discovery of true deep eidetic content derives through the glowing black aura. The human organism translates easily through the glowing black aura.

Vril appears in thready channels which completely permeate the inertialized environment of the apparent world. Vril auras impact and dissolve inertial space in concentrated points of the environment.

White ray sheaths mark the inertia-dissolving trails of highly accelerated eidetic transactions. Eidetic transactions combine natural in Vril sheath displays. Ground sourced white ray sheaths are observed. White ray sheaths mark Vril paths. White ray experience is experience of extreme Vril activity. These are dangerous to organismic integrity. Bright raylike eidetic transactions are seen passaging through aerial routes. Vril threads form the core of each such sheath. Aerial white ray sheaths mark Vril transactive paths.

The world is flooded with eidetic images. The apparent world is a Vril multi-juncture arrangement of eidetic terminals. Inertial dissolution, fracture, deformation, and distortion, follow Vril eidetic world transactions.

Vril eidetic worlds project the purity of experience which have been called "prana, aura, aether, atmosphere, eloptic, orgone". These are viscero-inertial manifestations of a deeper experience. Eidetic imagery and its experience is the fullness which these indirect descriptions represent.

Eidetic contact is the key to comprehending archane knowledge in total context. The mystics knew that universal intelligence permeated every experiential thing. Things not known or permitted were relegated to the insensate Vril worlds: things forbidden because of our inability to engage them. Alchymy was totally dependent upon eidetics for its source and operative mode. Eidetic energies are surging in the Vril structure. We intersect with them through material contact. Eidetic worlds reveal select axial centres which concentrate distributed awareness across space axes.

Vril penetrates and collimates in organisms to release sudden eidetic experiences. Projective worlds exist independently in absence of projected forms. They may be located through their projected materials which respond to their presence.

All materials respond to some degree with the local Vril channels. All materials are viscero-eidetic when touched. Eidetic energies are surging in the Vril space-structure. We intersect with them through material contact. Eidetic worlds reveal select axial centres which concentrate distributed awareness across space axes.

Materials are needed for the interception of eidetic knowledge. Materials are the detectors by which eidetic knowledge is gleaned. Study of earth batteries, undersea communications, and aerial batteries, and lightning rods demanded study of the foundation of charge generation from a radionic view. To comprehend the differential behavior of metals in lightning rod patents one necessarily became engaged in the study from the radionic considerations.

Radionic study alone does not suffice since lightning rods and various materials exhibit specific behaviors not explained through rates. Auric studies also did not explain why magnetically charged lightning rods would shield from lightning strikes. Convoluted rod forms exhibited shielding ability equivalent to platinum. This equivalence was determined to be an alchymycal one (D.Winter) and necessary study toward that end was engaged.

In testing minerals and metals for their conscious conductivity and content I discovered that consistent permeating viscero-eidetic impressions come both through free space and in direct physical contact. Special regard for the alignment, orientation, and disposition amid the stratified world revealed that minerals and metals may be Vril activated in excess of their native states. Vril junctures and local deep channels effect marked alterations in the viscero-eidetic content transacted through tested minerals and metals.

An arrangement of chemicals, minerals, metals, crystals, massive stones, jewels, precious metals, electrical componentry; stellar, planetary, solar, and lunar light was secured for empirical testing. I began by simply approaching each isolated form in order to sense all and any subjectively received impressions which might be projected from the minerals and metals.
While in several instances sensate discharges from object to body provided some degree of impressional reception touch contacts worked best.

Touch contacts provided viscero-eidetic experiences of surprisingly consistent detail and content among tested minerals and metals. Charts were made for each experiment. Each eidetic world is living and active. Each gives differing co-

existent experiences. These are each balanced and kept in withdrawn states by the alien presence of inertial space: until released again. The powerful transmelding of every potential Vril eidetic world will fulfill and complete the lost essential holism of our apparent world.

Ours is a world devoid of vital quality and essence; a pressured world experience where inertial space separates, distorts, binds, quenches, and limits the synaesthesial free-flow of eidetic worlds. Merging interpenetrating eidetic Vril worlds co-exist. This is experientially ascertained through the use of various material contacts and material configurations. Minerals and metals are windows which transact with their parent Vril eidetic worlds. Vril eidetic experience alters considerably in various material configurations and geometries.

No progress is made until a detailed study of materials and material configurations begins. We must touch and handle materials in order to determine their eidetic contents. Eidetic imagery and absorptive experiences are never forced: they must proceed from the substance being examined.

Such transactions expand the mind only when experimentation is made with regard for the Vril channelry in one's own district. Alignment of experimental work space with these underground Vril channels is absolutely essential in making these empirical determinations. One must make provision for ground access. The use of a ground rod is highly recommended. Testing materials for eidetic content requires Vril contact.

The experimental arrangement must engage materials and material configurations with Vril directly. Experimentation may also proceed in darkened rooms preferably. The "eyes-closed" method serves Vril sensory system well.

Numerous patents detailed anomalous activities when ground connected. These behaviors required a concise and thorough explanation. I believed that a mysterious foundational reality was responsible for all these systemological anomalous phenomena.

Rods, poles, and towers interconnect Vril concentrations in space and in the ground. Specific spatial poise is required to locate and connect space-Vril energies. There are aerial Vril points as well as ground Vril points.

Minerals and metals give Vril eidetic transactions. Grounds effect special experiential transactions. Material configurations give Vril eidetic transaction. Relational material configurations transact Vril eidetic experience. Relational holisms transact Vril eidetic experiences.

Vril threads supply special ground connectivities. Vril threads supply special aerial connectivities. Vril ground is succession of subterranean material contacts. Vril aerial is succession of auri-celestial Vril thread contacts. Vril thread contact is ground. Vril contact is aerial space contact. Vril worlds transconnect via threadways.

Vril extensions transconnect Vril eidetic worlds. Vril extensions via material contacts engage regional Vril consciousness. Material contacts reveal unsuspected eidetic presence in local surroundings. Native minerals and metals (mineral, metal, crystal lodes) permit first order eidetic experiences. Vril tufted aurae are experiential.

Kilner observed auric striations but did not engage experiential translations through those aurae. Inertial glowing haloes are non-dendritic and non-experiential. Vril designed appliances serve sensitives and ease translatory experiences among the eidetic worlds. Specific Vril thread discharges transact Vril eidetic worlds. Vril thread discharges display luminations through traversed regions. Vril thread discharges luminate with colorations when impacting inertial space.

White ray groupings are white ray sheaths which surround Vril thread discharges. Black ray groupings are black ray sheaths which surround Vril thread discharges. Vril eidetic world experience is participational sensory communion in meta-dimensional regions. Vril eidetic experience surpasses 5-sensory stimulations. Inertial appearance remain primitive 5-sensory stimulations devoid of eidetic content.

Inertial Technologies radiate excess inertia. Inertial technologies collimate inertial space. Extreme inertial technologies reveal Vril (Tesla).

Inertial luminations represent no meaningful signal. Vril luminations are true holistic light. Vril Light generation requires only Vril configurational
amplifiers.

True Vril aurae engage meaningful eidetic focus of consciousness. Vril Science seeks the dissolution and dispersal of inertio-auric detritus.

Vril Science selects and studies only eidetic meaningful experiential engagements. Careful observation of inertio-aurae during Vril transactions the contractile response of inertial detritus. Inertial detritus is contractile during Vril transaction. Vril transaction intensifies and extends Vril striated aurae. Vril engagements magnify and expand Vril striations.

Vril threads tunnels through space and ground. Vril threads travel along the ground surface. Vril energy is focussed along specific points of the ground surface. Vril threadways appear glowing eidetic when passaging in and through the ground. The eidetic glowing threadways were erroneously equated with subterranean water by dowsers.

Vril threadways are surrounded in eidetic transactions of experience. Vril is the very generative source of consciousness. To peer into Vril is to experience translations of mind and experience. Vril eidetic transactions are not merely the articles of sensation. To develop Vril Technology is to rediscover the connective linkage of the universe. To develop Vril Technology is to rediscover the deepest experiential communion craved by all sentient beings.

Vril phenomena explain eidetic conditions observed in nature. Vril is conducted by all materials which it generates. Substances each manifest a specific eidetic node which surrounds their enclosed eidetic glowing Vril threadline. The enclosed Vril threadline is the generative source and support of the material being studied. Vril pro-creates upon the basic existential eidetic which it fundamentally generates. Vril inflects, permutes, and surmounts its own foundations. Each such stage is a Vril Template.

Eidetic contents are spontaneously transmitted through Vril articulations. Humanly arranged artistic channels transduce Vril modulations directly. With Vril the need for exces-

sive human code is eliminated. Code free channels are found in singularly sustained ultra-harmonic sounds. Innate eidetic contents and evidence for space-distributed intelligence is revealed when monitoring telluric and aerial sounds. The need for excessive articulations of code is eradicated through Vril modulations. Vril designs its own hieroglyphs.

Eidetic contents are directly transmitted to recipients through Vril articulated designs. Vril culture consists in absorbing and communing with pure Vril eidetic contents. Departures from the immediacy of the apparent world are easily achieved through Vril articulations. Vril threads guide the human organism into deepest eidetic contents of the Vril World. The Vril World is the true World of eidetic content. Auras are translatory agencies.

Vril power points are sensed throughout the experiential spaces. Fixed Vril power points are ordained. Fixed Vril power points are found throughout experiential space. Vril points can be located in aerial space and ground. Vril power points can be interpenetrated by material imposition. Tremendous empathic and unexpected energetic manifestations are conducted through such material interpositions. Vril reactions define all mysteries. Vril presence generates all unexpected conscious activities. Vril Science explains all scientifically observed anomalies.

Vril is self-determinate. Vril expresses the sensate qualities of experience. Vril expresses the insensate realities which exceed our immediate experience. Vril is natural intent. Vril inflects into new expressions. Vril spontaneously permutes into unexpected qualities. Vril is self-generative and self-sustaining. Vril generates and permutes itself from nothingness.

Vril threads generate hieroglyphic connective terminals. Eidetic experience translates the human organism by direct conduction with Vril dendritic threads. Vril threads establish conductive forms in the human organism. Auras extend feathery vril inflectional threads.

Ground Vril concentrations provide the most potent interactions yet known. Ground Vril densities achieve dramatic effects in both human matched conductions and energetic displays of power. Regional climate is Vril-resonant. Regional climate is a complex range of empathic and metaphysical transformations. Empathic experience includes the unexpected activities of archane universal worlds. Vril ground concentrations represent boundaries between metaphysical and inertial spaces.

Human involvement with specific elements represent the civilizing activity of Vril. Vril is most powerfully conveyed through iron deposits. Vril conduction through carbon represents another major human resonant axis. The human organism is largely composed of both elements. Carbon and Iron are the major human resonant elements. Most technological systemologies employ these very materials at their core.

Iron lines composed all early telegraph systems. Vril conducting iron lines transmit exceptional degrees of clarified eidetic contents along with encoded signals. Powerful empathic communications through iron telegraph lines continue despite removal of artificial activations and signal applications.

Ground connected artifice necessarily conducts Vril. Ground connected artifice and component necessarily becomes Vril transactive. Vril threads manifest directionality. Vril threads arrive at ground surface from the depths of ground or space.

Ground surface is the major experiential interactive zone. Eidetic manifestations at ground level resemble fountains of sensual experience. Emplacing ground plates or aerial plates forms conductive linkages within the incoming auras. Vril eidetic transactions may then become strengthened. Strengthened eidetic transactions may become more sensate through time. Space is a Vril-glowing black dendritic mass. The ground surface is traversed with horizontal and vertical Vril threads. Sentient experience is derived in and among these Vril-ganglial interconnections.

Vril inflection sites release eidetic transactions. Such sites become Vril thread connections through human aid. Vril technology is participation with Vril itself. Human agency cooperates and co-structures with Vril intent. Vril responds to human need. Vril generates and sustains human consciousness.

Vril points release special permutative and generative powers. Vril power is released to human benefit when properly detected and joined to appropriate artifice. Cooperation between human agency and Vril generates civilization. Vril activations are achieved through Vril Technology. Vril Technological artifices are driven into Vril active points. Access to Vril points releases Vril to the needs of the surface.

Vril eidetic transactions are experiential spaces. The glowing black Vril eidetic node is the fundamental conscious state. There are endless Vril Eidetics in the black glowing Vril eidetic transactions. Black glowing spaces are the ultimate resonant Vril nodes. Certain arrangement provoke the spontaneous discharge of eidetic transactions. These discharges shudder and pulse into grounded materials. The degree and order of eidetic pulsations depends upon the grounded materials. Eidetic transactions display differentiations when conducted through material boundaries. These differentiations spontaneously blend, pulsate, discharge, and interact.

The interplay of Vril amid natural transactive cavities, chambers, vaults, halls, shafts, caverns, ribbings, arches, cellars and crypts exceed the Vril active potential of free space. Vril labyrinthine arrays are necessary to Vril activations. Eidetic attention must be forever upon the natural spaces: geology and space. Composite conductors differentiate Vril through each section. Differentiation represents Vril spontaneous self-generation.

Eidetic transactions are glowing spaces. Eidetic transactions are not particulate or gaseous. Sensation and awareness comes from Vril. Vril eidetic is not inertial eidetic. Vril Eidetic projection is experience.

Vril reactions are seen in every material configuration. Vril reaction first alter and influence the mind. Overlands are Vril activated. each land is known by the qualities which Vril emanates through their material composition. Ground material determines subterranean Vril differentiations. Vril activates all overlying materials, arrangements, and design composites.

Lamps activate and direct pole eidetic transactions. Vril differentiation becomes the predominant feature of material

configurations. Vril is self-sufficient. Vril is spontaneously self-generating. There is no need to supply artificial interruptions in Vril systems. No correlated activities or extra power is required in Vril Technology.

The eidetic transactions of grounded metal reservoirs self-expand. Vril supplies the self-generative process. Spontaneous accumulation and discharge of eidetic transactions from grounded metal reservoirs is the result of Vril presence. Vril can provide impulses and motance. vril is the natural and pure energy of the universe. Vril requires no extra applications to express qualities.

Certain materials are highly eidetic node ray active. The chief joy os Vril sensitive individuals is the experiential quality of Vril reactions. Eidetic transactions are active experiential space. Vril emanates space. The experiential Vril Eidetics in which sentient beings exist is Vril- generated.

Some transmitter designs projected incoming Vril threadways deep into the ground. These threadways caused response in the deep Vril causeways through which regions are referenced and joined. The resulting modulation of potent Vril channels produced highly directed transmissions of eidetic intent. Baron Karl von Reichenbach studied the spontaneous luminations of all materials in eidetic space conditions. Inter-eidetic transactions produce luminations. Tesla studied the spontaneous appearance and disappearance of electro-detrital charges in materials. Such detrital formation is constant. Eidetic transactions transact with the very Vril space in which they are generated. Such pro-creative activities vidence the Vril attribute of eidetic surmontage. Radionics studies resistive rates and auric interactions.

Geomancy studied the earth-line matrix of sacred spots and leylines. These empirical sciences were both largely confined to surficial examination of phenomena.

Vril science reveals the deep experiential potentials releases in minerals and metals, material aurae, and local space alignments. Vril science is experiential empirical science. Vril boundaries are impenetrable.

Sentient beings access Vril hegemenous related regions via material windows.

The appearance of material substances and the qualities and attributes of materials derive from Vril eidetic projections. Vril worlds project the elements. Substance attributes are projections of Vril resonant eidetic worlds. Self-modifying Vril world permutations alter all elements. Permutations in one Vril world may alter materials in many Vril worlds.

Neurological sensitivity precedes magneto-electric detrital discovery (Galvani).

Vril eidetic worlds generate specific extraordinary minerals. Minerals, metals, jewels, and crystals differ in their degree of eidetic experience. Vril axial contact is required for eidetic transactions. Off-angle contacts yield inertially contaminated experiences.

These Vril points suffuse and sustain vitality in the devoid apparent world infra-structure. Vril revelations provide shortcuts through which we achieve futural science. Vril eidetic messagings direct and re-structure human consciousness into its deepest potentials. Vril eidetic consciousness breaks the inertial bondage to the 5-sensory degenerate perceptive mode.

Vril thread dynamics seem to proceed in deranged and mysterious expressions. The observation of this strange Vril thread language does not enjoin the examiner with an eidetic experience. Touch contact may quench the activity of certain Vril transactors: gaps are required. Vril energy in gaps often increases with increasing distance from a design.

Conscious reference determines experiential content. Vril Science recognizes only eidetic experience achieved through material contacts as accurate experiential reference. Vril Science gives an experiential world-view which necessarily differs from objective models presented during the last 500 years.

The reality of eidetic transactions through material contacts annihilates the validity of our excessive reliance upon open-eyed information. The deep Structure of experiential reality is eidetic and Vrillic in nature: differing from the 5-sensory experience of the apparent world.

Eidetic experiences are whole world experiences. Specific groups and families of elements reveal specific range and quality of eidetic experience and can be selectively used. Specific groupings and families of elements provide needed hardware for Vril Technology.

Vril eidetic transference is achieved through material contact. Vril eidetic experience is entuned through material configurations and arrangements. Vril eidetic experience in most material configurations requires contact. Vril ground thread interaction intensifies near specific natural materials. Vril Technology arranges specific strong Vril conductors for Vril eidetic experience.

Materials are natural Vril World connectors. Specific materials permit Vril eidetic experiential correspondence. Questing for new Vril high-conductive materials brings new experience. Vril eidetic material conductors must be carefully entuned through special designs. Eidetic entuning devices utilize specific human Vril-sensitive matter. Vril directs awareness.

Vril insensate threads are sensed as prickling sensations when contact is not well-designed. These actions were called "electrical" because of certain physiological sensations encountered when absorbing them. Vril may release inertial detritus (charges) in the flesh because of absorbed inertial space.

Vril eidetic absorption expands consciousness in Vril eidetic worlds. Vril eidetic absorption eradicates simple inertio-sensory blocks. Vril Science is discovered via Vril eidetic connection. Minerals and metals, material configurations, and configurational alignment must be eidetically experienced, tested, and utilized. Clustred material structures effect inertio-sensory constrictions.

Vril Science is not mechanistic. Vril Science is empirical and experiential. Vril Science discovers experiential meanings through eidetic contacts.

Vril Technology designs and arranges experientially derived componentry. Vril ganglial threadways remain in participating organisms. Vril experiences require place-visitation. Vril experience exalt consciousness and virtue. Vril threads are indivisible portions of their parent eidetic worlds. Vril threads give trans-regional experience.

LIGHTNING RODS

Vril active geometry is evident in Lightning Rods. The use of inexpensive metals in geometric configurations equals the use of the more expensive Vril conductive materials. It was suggested that these metals are alchymycally equivalent to the noble metals (D.Winter). Vril reactivities in multiple metal configurations are eidetically equivalent to those of noble metals through geometric reconfigurations and manifolds.

The purpose of Lightning Rods is to control consciousness throughout a Vril specific region. The protection of a building is an ancillary purpose of the Rods. Aerial arrays conduct Vril from the ground and permit Vril inflections to be freely expressed in space. Eidetic reactions surge in the system. Certain designs produced super-radiant non-electric eidetic projections which escaped from their aerials through enormous distances. Other designs relied upon the self-determined articulations of Vril-threads in the ground to make specific contact with intended communicants.

Lightning Rods were once universally accepted as causative agents of storms. The use of lightning rods was also attended by freakish phenomena which disturbed the countryside. Lengthy dryspells or excessive rainy seasons provoked villagers to fury.

Dr. Joseph Priestly describes several Vrillic phenomena which preceded and attended a severe electrical storm. He describes much more than a regional electrical event and pays especial attention to the inertio-detrital figures which are developed during a Vril surge.

The historical development of lightning rods came in special stages. The use of platinum came first as traditional lore. Magnets were then employed as special shields. This was followed by a period where Galvanic systems were used (metal combinations) to service those of modest means. The final development include the use of ground stakes and assemblies to "draw the fluid".

These claims are mocked unless sufficient knowledge of Vril processes is possessed. Vril process involves tremendously powerful insensate radiances. A very small quantity of platinum is sufficient to guard against a majority of negative weather influences.

Vril stimulates the enlargement of eidetic transactions. Materials do not properly reveal their true identity in the aerial state. Materials must be grounded in order to reveal their truest identity. There are several patents which illustrate the methods of modification used to achieve these results.

Vril surges in certain materials strongly dissolves and agglumerates inertia. The manner in which inertia is attacked, penetrated, scattered, and dissolved is material-specific. Grounded materials strongly conduct Vril. Material conductors of Vril emanate specific eidetic transactions.

Grounded platinum conducts Vril. Vril threads tunnel through platinum and release an inertia-repelling eidetic transaction.materials which are highly eidetic node ray active. Platinum is such a material. Platinum was anciently prized for its protective functions. Early Lightning Rod designs employed Platinum as a rule. Platinum coatings were employed where no Platinum was to be had in quantity.

The working class could not afford the protective shielding of Platinum Lightning Rods and relied upon alchymycal applications to produce equivalent protective effects in combinations of Zinc, Copper, and Iron.

When eidetic transactions of materials combine they interblend and may permute. Permutations are not degenerate products. Permutations are new and unexpected proportions of qualities. Permutations are generated in specific material configurations. Configurations involve 2 or more materials in proximity. Vril stimulates the enlargement of eidetic transactions. Materials do not properly reveal their true identity in the aerial state. Materials must be grounded in order to reveal their truest identity. There are several patents which illustrate the methods of modification used to achieve these results.

Vril surges in certain materials strongly dissolves and agglumerates inertia. The manner in which inertia is attacked, penetrated, scattered, and dissolved is material-specific. Grounded materials strongly conduct Vril. Material conductors of Vril emanate specific eidetic transactions.

Platinum is such a metal. Grounded platinum conducts Vril. Vril threads tunnel through platinum and release an inertia-repelling eidetic transaction. Platinum repels inertial spaces in the natural environment when conducting Vril. Such metals are useful as shields because they through out a powerful eidetic extension over large volumes of ground. The mere presence of the platinum pole was sufficient to prevent lightning strikes.

Archane context and the knowledge of correspondency are lost when eidetic experiential reality is forgotten. Alchymy relies upon eidetic content and experiential potentials. There were eidetically active materials which could be synthesized (Meitzger).

Lightning rods are Vril eidetic world projectors: magnifiers of other worldly presence. Lightning rods do not conduct the detritus at all. Lightning rods are projective dissolvers of inertial presence. Twisted zinc, copper, and iron composites are alchymycally equivalent and effectively as capable of protecting a house as well as a point of pure platinum.

These remarkable empirically determined truths passed unnoticed by most scientific students. This cannot be explained by simple Galvanic science; and is certainly not explained by electrical science which is unwilling to discuss the issue. Inertial science rejects all possibility that various metals effect special protective qualities from lightning strokes.

Vril Science explains the mysterious variation among metals by the empirical discovery that metals project eidetic worlds into our own world. The eidetic transaction dispels inertial conditions and translates portions of another world into our own. All minerals and metals are dimensional windows.

The magnification of their eidetic contents requires skill in magnifying the degree of translation. Eidetic translations effect dissolutions of the inertial space which they penetrate and replace apparent conditions with more beneficial ones as designed. World conditions can be transmuted by such means; and alchymysts actively engaged in just such activities on a regular basis.

The use of magnets to provide special protection against

lighting was noteworthy (Bryan). Examined from the inertial viewpoint such action cannot realistically occur. Physical science defines the magnet or lodestone according to polarity and symmetry of field. Inertial science dispenses with the notion that magnets can project suitable protective influence across vast reaches of space. Emerging Vril eidetic worlds generate dramatic effects in inertial space.

Magnets may be buried in material configurations to produce strong eidetic node ray eidetic transactions in the surrounding space. The use of magnets to provide special protection against lighting was a noteworthy chapter in lightning rod development. Burial of magnets with sulfur blocks increases the eidetic node ray content and brings the protective condition required (Bryan). These configurations also bring detrital currents. Earth batteries can be designed from these considerations.

Metal dust composites alter eidetic node of magnets positioned in their midst. Such configurations focus the eidetic node ray extension at the poles considerably. This results in extension of the eidetic node radiant eidetic node and subsequent protective power. Platinum repels inertial spaces in the natural environment when conducting Vril. Such metals are useful as shields because they through out a powerful eidetic extension over large volumes of ground. The mere presence of the platinum pole was sufficient to prevent lightning strikes.

Magnets are also powerfully eidetic. They have been employed as shields against all manner of negative influence including lightning strikes. Empirical examination of such designs (Bryan) reveals that a small magnetic charge is sufficient to counteract the conduction of Vril and its subsequent detrital products during adverse weather conditions.

Magnets effect powerfully focussed eidetic transactions. The use of magnets in lightning rods effected powerful and sharp vertical eidetic transactions. Such sharp focussing of specific eidetic content proved capable of scattering and dissolving electro-detrital accumulations.

Anomalies and anomalous activities occur in inertial space because of the activity of Vril eidetic world transactions. Vril technology and Vril activated technological components manifest numerous consistent anomalies in inertial space. Emerging Vril eidetic worlds generate dramatic effects in inertial space."

Vril inflections precede the appearance of lightning which release sudden shockwaves, vorticies, currents, waves, and other inertial patterns well before charges concentrate and lightning flashes.

Aerial batteries do not derive their electrical outputs from "static in the air": most aerial batteries are grounded systems. The use of extreme electrical tensions to produce modified vril thread discharges was notable in one designer's wonderful schemes (Hettinger).

Lightning rods were designed for the working class who could not afford the expensive protection offered through platinum. Designers twisted and convoluted less expensive metals in curious topological manners to provide remarkably equivalent protective actions (Mitchell). The convolute internal structure of these lightning rods may be experimentally verified as vril eidetic transactors of exceptional effect (Stearns). Twisted metallic composites were empirically tested (Row). Several designs employed geometrically re-configured common metals to achieve special and powerful protection for modest homes (Martin, Cole).

Designers necessarily tested their configurations on tall lightning rod "blocks". In this arrangement the inventor would counterpoise the test design in order for a "lightning strike" to occur. On mountain ledges or exceptional towers these tests could prove the validity of claim made toward a patent. If a claimed action did not prove to have a validity it was discarded. American patents are not granted without working models or court-examined experimental arrangements. The chief benefit of the COMPENDIUM is its validity as a legal document.

Lightning rods achieved their claimed results. We must also recognize that these results were proven true in specific locations: special points where geomantic topography rules results. If platinum does not shield against inertial detritus (lightning) then perhaps regard must be made for place, alignment, and position. It seems obvious that lightning rod inventors knew which materials to utilize in each specific location. What material configuration would work for one point might not hold true in another point.

Sulfur offers powerful eidetic transactions with tendencies to spread outward above the immediate ground. Its eidetic world is one which brings images of bright sunlight. Experience of these realities will convince that sulfur used in this manner actually dispels storms by translating a perpetual sunny weather pattern into an area.

Originally intended as the grounded section of a wondrous lightning rod assembly we see in Bryan's earth battery an early predecessor of work done by L.Hendershot. Energies which powerfully emerge from the ground are dealt with in special designs made to absorb and re-direct detrital refuse (Barber). Bryan's amazing use of the sulfur block as grounding medium is significantly Vrillic.

Appreciation for the fact that inertial detritus emerges both from the ground and from the sky is mentioned in several patents (Lyon). Aerial battery do not simply absorb static electricity from the sky: they are grounded systems. The tendency toward heavy reliance on inertial detritus (rather than on Vril transactions) culminates in the designs by Palinscar: which required large networks to develop sufficient energies for usable power.

Grounded elevations prove to be no protection against electro-inertial detritus at all (ground lightning, aerial lightning) when their eidetic transactions are inappropriate. The use of isolated copper, isolated zinc, or isolated iron points does not provide protectively appropriate eidetic transaction to protect against aerial lightning.

Zinc and iron provide protection against the ground detritus; with iron exceeding in ability. Each of these have groundward correspondence and do not effect dissolving power in the volume of inertial space above.

Certain material configurations enhance Vril transactivity and depress inertial detritus. Certain material configurations enhance the inertial detritus and depress the Vrillic transactivity.

their are designs which release greater eidetic transactivity. There are designs which release greater visceral transactivity. There are designs which magnify inertial products of many varieties. This accounts for the "different outputs" of each design. This accounts for the "different species of electricity" noted among different devices.

Designs differ in their ability to "produce electricity": there are those which produce varying proportions of "charge and tensions". Among the aerial and earth batteries we have realized a great many of these species.

Components and systems successfully operate as valuably agencies of human benefit only when acting as strong Vril eidetic transactors. Lightning rods operate as protectors because they are powerful eidetic transactors. Platinum proved to be protective in absence of ground assemblies. Vril eidetic transact through platinum explains why lightning and other inertial residues avoid such minerals and metals.

Proper placement and alignment is the essential element of design when using platinum (Spratt, Cole). The eidetic world projection which emanates from the platinum point gives experience of stellar heights and bright clear night skies...a journey which elevates the mind above the cloud-tops to view the opened stellar expanse.

It is the quality and content of the eidetic experience transacted through a material configuration which defies the inertial environment. Eidetic transaction dissolves and disperses inertia. Storms are disrupted and scattered by Vril eidetic projectors (Reich). The eidetic content of the transactive experience is the essential element as regards lightning rods.

Zinc projects eidetic experience of the subterranean ground. It therefore will not be a good sky-lightning protector. In combination with platinum however, it proves to be an excellent protection against ground lightning. Each material configuration must be experimentally discerned from the eidetic foundation. Designers empirically required that lightning rods be tested. Comprehending why they worked as specified was electrodynamically problematic. Differing metals and foldings do not measurably effect important electrical parameters when dealing with lightning. Therefore a far more significant foundation was required.

Stationary placements of material configurations alter the entire experiential transaction of Vril in a region. Vril transmutations do occur with specific natural stations. The eidetic world which projects "platinum" may be translated via specific common minerals and metals in special geometric symmetry. The success of certain lightning rods employed common metals because their eidetic worlds may have matched platinum transactions. Vril technology emplaces material configurations for the magnification of accessible Vril eidetic transactions. Specifically emplaced material increase Vril eidetic and visceral experience in a region.

Aerial emplacement of material terminals must be carefully delineated: aerial nodes must be reached and linked above grounds. In certain instances aerial and ground junctures may be reached and linked. Vril eidetic world experience gives the key to meaning and organism wholeness. Natural Vril junctions and nodes permeate experiential space.

Eidetic transactions dissolve, scatter, distort, shear, twist, whorl, pattern, shape, geometrize, impel, and fracture inertial space concentrations. Lighting strokes are detrital patterns which are the results of inertial concentrations. Detrital accumulations and concentrations self-discharge.

The cloudbusters of Reich are specialized lightning rods. Their inclusion of water channels projected potent eidetic node rays into sky and space through metal tubes. The enormous power of such devices prove their effectiveness in extending Vril threads into space while dispersing aerial inertia. Reich's cloud-buster is a special Vril projector which requires a special kind of ground. The use of iron BX cable as the grounding line into water is significant. Inertial detritus is brought into the ground site in a conical concentration which is dangerous to those who manage them. Care must be taken to avoid the inertial flux which is drawn out of the aerial region being "worked upon".

Lightning rods operate because of Vril eidetic transactions not because of mechno-inertial dynamics. We do not make consideration of received inertial detritus. Inertial technology is not our goal. We seek the eradication of inertial technology.

Numerous Galvanic circuits occur between natural configurations (off-shore islands). Noticeable Vrillic correspondencies among bay-enclosed monuments are noteworthy (Governer's Island and Bedloe's Island in New York Harbor). Powerful shocking aerial currents are sensed emanating from the copper plating on the Statue of Liberty. These thready radiations are Vrillic but appear whitish because of their dissolving power on surrounding inertial space.

These thready radiations pass to the adjoining island (Governor's Island) and to nearby Robin's Reef (the shell of an old abandoned lighthouse). Galvanic science explained these aerial transactions as auric current exchanges through space. Galvani experimental verification that such currents exist. Volta could not account for the aerial experience of visceral-sensations between large dissimilar metal plates.

The effects of weather vanes on district tone are noticeable. The emergence of house-protecting sceptres follows the long tradition of European talismans. Sceptres placed upon homes were numerous in structure and material. These designs began to be used to protect against lightning and weather conditions.

Radionically designed sceptres were originally designed to protect homes from negative entities and influences; and may yet be seen surmounting the towers and parapets of Victorian architecture. These bring vitality into homes and surrounding districts.

Human attention is powerfully drawn to these structures and components. Their effect upon local weather patterns was traditionally accepted. Angry villagers tore down several weather-vanes when it became apparent that these were bringing anomalous weather patterns.

Vril technology must take care never to configure improperly aligned structures.

The truest function and purpose of Lightning Rod forms and rooftop ornamentation is to alter conditions and regional

climates of consciousness. The foremost Vril potential of Lightning Rods is the control of consciousness and the proliferation of positive experiential climates. Weather control is an ancillary effect of these primary functions.

Rooftop ornamentation has been historically linked to spiritual warfare. The placement of sceptres and wands upon rooftops has ancient origins. In Tibet these designs are made of woven organic matter which greatly resemble flat multiple plate pancake antennae. These forms ward off and entrap negative influences which attempt entry from aerial routes. Special design forms have been used in embellishing towers. These forms enhance ground Vril contact outward into other space.

Gothic Cathedrals feature several variations of rooftop geometries. Cones are frequently surmounted by spheres of stone. These formats may be ribbed. There may be several smaller spheroid forms along each ribbing which lead to the tower crown. Such forms are extremely Vril active. These are powerful Vril discharge points. Intense Vril threads connect directly into other space from these forms. Ribbed pyramids are exceptionally potent as bilocators.

Space are the experiential fluorescence of Vril channels. Vril threads define human experience of space. Spaces are Vril eidetic transactions. Distinctions of space derives from Vril. Vril in ground causeways emerges outward in dense dendritic threads. These define experiential qualities of specific directions and orientations. Space along each Vril threadway differs greatly in quality. Viewing stars and celestial objects is Vril dependent. Vril qualities determine what we experience in space.

Vril interworld communications effect environmental dynamics. Lightning rods, aerial and earth batteries and all technological componentry of communications are Vril eidetic world conductors and transactors: they change our world. All minds are drawn to them because of the conscious generative potential which they bring. The angelic Mercurius Herald is often pictured as the messenger of these experiences. It is interesting that the mercurial substance is not a literal metallic liquid. Vril is the dark, wriggling, generative energy which is seen passaging through the depths of deepest ground and space.

The incidental operative success of lightning rods aerial and earth batteries derive from Vril world eidetic transactions in the apparent world. Inertial nullifications and deformations distinguish strong Vril active eidetic world conductors.

AERIAL BATTERIES

Galvani sensed the existence of space stresses between and among dissimilar metals long before Volta showed it possible to produce inertial detritus in special material configurations. Aerial batteries and material configurations made by Galvani proved to be vitalizing and beneficial to body and consciousness. Their outputs were not electrical and could not be measured on the most sensitive gold-leaf electroscopes at all however strongly received in the viscerae.

The designs of Galvani are fundamental Vril active configurations and transact enormous eidetic world experience. Stationary placements of material configurations alter the entire exper transactions of Vril in a region.

Vril transmutations do occur with specific natural stations. Vril technology emplaces material configurations for the magnification of accessible Vril eidetic transaction. Specifically emplaced material increase Vril eidetic and visceral experience in a region.

Materials are eidetic reservoirs. The intensity of eidetic interactions produce observed accumulations of inertial detritus. Such detritus is accumulated in the rigidified inertia of matter via insensate Vril transactions. This physical manifestation evidences the acquisition of detrital charge from nothingness.

Eidetic transactions of metal reservoirs are intriguing. These eidetic transactions expand continuously into inertial space (Mesmer, Galvani, Kilner, Reich). Mesmer used the eidetic nodes through moss in transaction with iron slag to produce extremely vivifying visceral currents. Galvani discovered the visceral reactivities of metals in proximal arrangements. Galvani recognized the visceral reactivity of the ground with space. Aerials and ground gave Vril current threads. Vril self-inflects in specific material assemblages; generating and projecting unexpected qualities.

Aerial emplacement of material terminals must be carefully delineated: aerial nodes must be reached and linked above grounds. In certain instances aerial and ground junctures may be reached and linked. Vril eidetic world experience gives the key to meaning and organism wholeness. Natural Vril junctures and nodes permeate experiential space.

Aerial nodes are linked via material terminals. Aerial terminals transact eidetic experiences with recipients. Special regional modifications are achieved through the use of special aerial-crowning jewels, crystals, and superior metals. Axio-vertical alignments and dimensions must be carefully searched. Vertically aligned Vril nodes which span aerial positions and ground positions are rare and notable sites. Nodal vertical alignments give exceptional and extraordinary eidetic experiences. Such eidetic transactions are brought into a region by the mere construction of special towers.

Recipients experience eidetic transactions communicated to them directly through the ground as a result of such Vril active towers. Aerial terminals display several eidetic nodes throughout their lengths. Earth and aerial "batteries" were configured in various material geometries to produce specific proportions of inertial detritus. Some of these were configured to transact with inertial vorticies (Dieckmann).

Other designs were biologically configured and having synaptic gaps (crowns) which both ground and surmount them (Dewey). Most of these aerial towers after Galvani utilize the inertial detritus resulting from Vril thread discharge-impactions from their grounded presence. Such social alignments must cease.

Aerial batteries of Vion, Dewey, Palinscar, and others exclusively employed various degrees of the detrito-productive aspects engaged through Vril eidetic transactions. These designs produced dangerously heavy electro-detrital charges. The natural process of static manufacture is the result of the natural Vril engagement of inertial space through and among

minerals and metals (Le Bon).Artificial elevations produce spontaneous accumulations of inertial detritus (Palinscar).

Naturally achieved elevations release and transact varieties of eidetic species (Vion). Aerial batteries respond to insensate (white raysheath) space vril modulations (Popov, Ducretet). Aerial batteries were later employed as special terminals in middle wireless systems which remained forgotten (Murgas, Shoemaker).

Certain aerial batteries employed the eidetic tuning effects necessary in transacting with Vril worlds and proportioning eidetic impacts with inertia in an elevated system (Palinscar). Others employed systems which made use of daylight earth-inertial fluxions. Remarkable designs defied electrical principles (Ward). The projection of Vril thread discharges and absorption of the same caused the aerial batteries of Ward to behave in unheralded manner.

Experiments performed with hollow pipe and rod assemblies proved that such configurations (when properly grounded and aligned) released powerful visceral eidetic Vril thread beams. These actually increase with intensity through greater distances. they are accompanied by a thrilling sensation which focusses upon the abdomen. There is definite accompanying heat which floods the beam volume.

The Ward Tower system made use of specific Vril placement to obtain excessive Vril transactions among Vril groundpoint junctures. A system of such towers (properly placed, configured, and aligned) could provide limitless Vril power for use in eidetic communications and conscious magnification. As detrital diffractors such devices produced sufficient inertial condensations to drive the code of telegraph lines. Their more wondrous power is largely left in modern times to the artists for aesthetic appreciation. The magick of lighthouses, turrets, towers, aeyries, and other precipices convey vast amounts of information to the recipient. The chief use of the tower was to gain communion with the heavens.

Aerial batteries are inertial detrital reactors. Aerial batteries arrange mixtures of inertial detritus from Vril potentials by design. The manner in which inventors have composed and constructed these several forms reveals remarkable distinctions in output. Output species mutually differ considerably among these designs. They are each known for their differences: a significant feature among this class of power generators.

The supposed identical manner of "atmospheric charge formation" does not produce identical products in each patent. Aerial batteries are eidetic tuners when properly constructed in their native state. Aerial batteries are white ray (sheath) conductors.

A fundamental mode of communications floods the universe. Eidetic transaction occurs along specific Vril lines which transact the apparent world. Aerial towers and Vril transactive terminals alter district and regional realities. There are ray orientations in which the human organism responds most favorably. This alignment occurs when facing the eidetic node ray axis of a Vril Channel. Galvanic aerial batteries can be constructed in a room in order to achieve these results. Care must be taken to align the large area metal plates with local Vril channels.

Positioned amid several geometric arrays provides eidetic node ray extension into the surrounding space. The region becomes eidetic node ray loaded. This condition is protective during storm times. Vril extension from ground enters buildings. Avalanche detrital process ensues when the energy contained in the Vril penetration of local inertial space is sufficiently great.

Vril projects through space at points to generate, sustain, and build up materials. Certain aerial batteries are the sites of prolific transaction which lead to transmutations. Early regard for geological and geomantic features were used to great advantage in effecting powerfully collimated transmissions to extremely distant recipients. Investigation of such transmission sites has been conducted by a few noted researchers (E.Dollard).

Aerial batteries are capacitors. Varieties of aerial batteries have been investigated through which other Vril manifestations are fractioned, selected, and magnified define the patent collection. Certain aerial battery designs extract only the detrital pressures of Vril interactions. Electrical components are magnified to exclusion in these designs. There are those aerial batteries which fraction and magnify eidetic transactions (Ward). These are capable of serving as wireless transmitting stations of conscious intent. Their forms have been repeatedly observed throughout the patent registries of early, middle, and late wireless communications.

Radio aerials are radiators of eidetic transactions and are terminals into space Vril distributions. Metals are eidetic radiators. Metals are potent eidetic radiators when grounded. Galvani measured eidetic radiances through both human and animal organisms. Metals held in the opened mouth emit eidetic radiances which may be felt. Meucci discovered the empathic potential of a charged wire. Meucci transmitted eidetic messages without the use of acoustic artifice.

The true purpose and function of every Vril Technological component is to transmit modified consciousness in human operators. Vril Science studies Vril and its potentials in order to collate knowledge of Vril reactivities.

The design of aerial capacitors has its first purpose in expanding human awareness through Vril. Parallel plate windows are aligned with Vril threadways to dissolve organically internalized inertia and release special vision. Vril aerial batteries fuse human recipients with ground Vril directly.

Systems through which extended vision may be achieved are specially configured materials which utilized ground and aerial terminals. Special communications are achieved when several individuals use these formats across great distances. Such vision enhancers are interlinked through aerial projection conduits. Natural Vril threadways and channels are their primary ground connections.

White ray sheaths mark the inertia-dissolving trails of highly accelerated eidetic transactions. Eidetic transactions combine natural in Vril sheath displays. Ground sourced white ray sheaths are observed. Aerial towers must not bring excessive inertial detritus into a district. The function of aerial batteries and transactors is to transact eidetic worlds with a district...to raise and unify consciousness.

Rooftop ornaments function as Vril battery-transactors.

Their presence atop buildings of all kinds alters the experiential environment of the enclosure. Aerial battery-transactors may also alter local situation via Vril-active groundpoint proximity. Weathervanes, lightning rods, and radionic roof ornaments are historically associated with weather control.

Vril threadways permit the experiential merging of whole worlds. Vril is the noumenous presence of place. Vril reactions are sustained, extended, and controlled through arrangements of specific materials. Vril transactors are created when material arrangements are directly linked with Vril threadways. Vril reactions transmute and modulate climactic conditions in whole regions of ground. Aerial batteries are Vril transactors which generate weather patterns.

The studies of materials along attribute parameters other than viscero-eidetic is largely futile and unnecessary. Vril technology depends on special knowledge of eidetic worlds and eidetic content of all Vril transactors and Vril reactors influence and alter conditions of climate.

Climate and weather are the results of Eidetic transactions. The spurious and tantalizing nature of weather is the result of mysterious spontaneous eidetic Vril world interactions in districts and regions.

Lightning rods and aerial batteries and earth batteries were by legend associated with weather control. The sense that specific ground points (wells, monuments, rocks, cliffs) do project a vibrant, modulating penetration is familiar to most sensitives. Vril is the moving presence.

The permeation of eidetic qualities despite inertial detritus (photic illumination) proves the suffusive presence of Vril threads through the experiential universe. Batteries are eidetic reactors in which matter in contact engages viscero-eidetic transactivities with inertial space.

Galvani designed Vril battery-capacitors. These were large metal plates separated by space. Stepping between these brings strange visceral effects.

Aerial Vril nodes are stationary conscious-radiant points which provide eidetic transactions through discharge to receptive organisms.

The use of aerial batteries to intercept the discharges between space-points and ground-points was used with success (Dewey). Specific minerals and metals are inertially occluded expressions of Vril eidetic worlds: contact with them engages the participant in strong (unforced) eidetic journeys. Aerial batteries emplaced in such ground-masses do bring extraordinary effects to a district. Such effects become the substance of local legend. Minerals and metals are Vril world windows. Some metals are never "struck" by lightning regardless of their elevated position and theoretically necessary vulnerability. Clearly geomantic anomalies occur in special grounds.

Wireless experimenters investigated these aerial Vril points with especial regard for geomantic position (Tesla, Marconi, Rogers, Fessenden). R.A.Fessenden designed later systems which entirely eliminated ground connection: engaging galvanic transactions among aerial metallo-forms. Proper aerial orientations provided the most powerful signal transfer with respect to ground. The empirical experiences of these researchers are described in their patents. Each gives the sense that some extraordinarily personal transaction occurs between device and environment.

Certain orientations differed in ability to transfer powerful eidetic content because Vril distributions are irregularly oriented throughout experiential space. Such research required facile movement of huge arrays. Most researchers abandoned this study. Ward was an experimenter who dealt with the anomalous tracking of "aerial electric currents". His design could be swivelled to "funnel" the aerial charge currents.

This arrangement is entirely non-electrical in primary function. Vril threads is the empowering energy. This design deserves close study. Experiments along these parameters has led to several eidetic discoveries. The use of dissimilar metals enhances the strong transaction of viscero-eidetic power.

Intuitive guidance led a few sensitive wireless researchers to establish their facilities atop specific Vril-active mountain peaks. Potent reactions and transfers were achieved at these specific sites. Extremely potent long-distance transfer of signals and eidetic content were achieved by surveying local Vril concentrations and Vril directionalities.

There is danger to the improper placement of aerial termini. Aerial terminals are sites where inertio-detrital concentrations take place when improperly aligned. Some buildings and points are anomalously struck with lightning throughout history. Aerial terminal configurations endraw Vril threads when provided specific projections. Aerial projections are position specific in every locale.

Vril science examines and locates aerial Vril node clustres. Distal magnifying Vril conductions transact enormous personal fusion in aerial terminals. Distal eidetic groundpoints foci gives enormous experience of stellar and planetary terminals. The sun is enormous and overwhelming when standing on specific points. Metals and minerals are Vril eidetic world terminals. They each give special eidetic connectivity with special worlds. Some Vril nodes connect us powerfully with a specific space world (planets, stars, lunar or solar bodies). On these points the experience of those worlds overwhelms.

The apparent World is a complex of Vril eidetic projections. Vril projections exist in arrangements and configurations of eidetic world terminals. Finding these and founding aerial terminals gives potent activities. Meaningful organismic experience is attained via Vril eidetic world contacts.

The study of Inertial dynamics is meaningless and subordinate. Vril eidetic worlds translate organismic experience. Lightning rods and weather vanes were traditionally perceived as conscious foci and transmuters of local climate. Vril eidetic world transactions extend organismic consciousness. Eidetic Vril world transactions release extra-organo-consciousness. Vril Science studies eidetic world transactions in minerals and metals, ground configurations and aerial space. Ground and aerial conditions modify material Vril eidetic transactions.

Vril Axes meet at Vril junctures. The arrangement of successful aerial batteries required both aerial material forms as well as ground configurations (Bryan). Neurological (viscero-eidetic) sensitivity precedes magneto-electric detrital discovery (Galvani). Galvani sensed the existence of space stresses between and among dissimilar metals long before Volta

showed it possible to produce inertial detritus in special material configurations.

Aerial batteries and material configurations made by Galvani proved to be entirely vitalizing and beneficial to body and consciousness. The designs of Galvani are fundamental Vril active configurations and transact in the visceral domain. Galvani studied auric effects occurring between separated metals. Galvani also studied metals in close proximity as well as contact metals. Experiments have replicated these effects. Holding a contact composite of copper (facing the body) and zinc brings tremendous eidetic thrill when facing a Vril trans-regional channel.

Grounded objects and aerial elevations spontaneously "acquire charge". Aerial nodes are linked via material terminals. Aerials transact according to the materials in which they project. Rods emplaced in rock are powerful transactors. Aerial terminals transact eidetic experience with local recipients. Lightning rods cannot be adjusted: they are fixed metalloforms. Aerial batteries can be adjusted: they can be used to alter, select, and adjust regional eidetic transactions which self-reference constantly. Use of rheostatic and capacitative modifications had been employed in many of the patent designs. These control features effected drastic local transmutations despite their electrodynamic perspective.

Special regional modifications are achieved through the use of special aerial-crowning jewels, crystals, and superior metals. Axio-vertical alignments and dimensions must be carefully searched. Vertically aligned Vril nodes which span aerial positions and ground positions are rare and notable sites. Nodal vertical alignments give exceptional and extraordinary eidetic experiences.

Such eidetic transactions are brought into a region by the mere construction of special towers. Recipients experience eidetic transactions communicated to them directly through the ground as a result of such Vril active towers.

Aerial terminals display several eidetic nodes throughout their lengths. Vril eidetic worlds generate specific extraordinary minerals. Minerals, metals, jewels, and crystals differ in their degree of eidetic experience. Trees extend Vril directly. Trees are natural Vril transaction sites. Poles are Vril transactors. Specific Vril transactors operate in specific Vril Templates. Poles and towers operate in contact with the ground through the Template of stratified apparent world. Vril enters and emerges through such aerial projections and short-circuits the horizontal stratified world of our experience. This is their chief power.

Aerials are especially potent with regard for Vril juncture connections between ground and space. Wood is a special organic material having high Vril conductivity. Compact capillary bundles of this vascular kind seem to effect extraordinary Vril conductivity. Stones which are threaded with mineral veins and fine capillaries are also notably Vril conductive. Laminar deposits of minerals provide special eidetic transactions of strong conductivity.

The towers of Ward are similar in form and design and purpose to lighthouses in which noteworthy eidetic transactions continually take place (M.Theroux). Aerial batteries mimic the Vril transactive abilities of trees and mountainpeaks. Some systems project energetic collimations of Vril beacons. Trees are natural aerial batteries (Squier). Trees are prolific Vril transactors. The granular articulation of wooden poles provides Vril with special conductive paths. Wooden poles maintain their Vril polarizations and enable strong Vril conductions.

Certain neighborhoods and districts lose their vitality when Vril is impeded and disrupted through improper placement of buildings and municipal configurations. When Vril eidetic transactions are magnified and properly engaged these districts sparkle once again. Such neighborhoods often retain some measure of ground-surface Vril transactions. Cathedrals and their attendant aerial terminals are notable eidetic transactors. Earth batteries mimic the organic behaviors of ores, lodes, and mineral striations. Earth batteries resemble mitochondria (A.Berkowitz).

Galvanic aurae and space tensions are non-electrical in nature; being electrical immeasurable though strongly visceral. Galvanic aerial batteries provide sensate experiences; felt through the chest and thorax as thrilling frictions.

Aerial batteries and assemblies manifest spontaneous self-directing angulating raysheaths from their points. Vril aerio-dendritic connections spontaneously self-organize when simple terminals are provided them; something which early wireless researchers discovered. This phenomenon is evidenced in Tesla's illustrations of his fixed-form terminals from which self-directing beams are shown assuming collimated paths.

Vril contacts define the terms "ground" and "aerial". There are relative ground and relative aerials. Each much be configured and properly designed to effectively intersect, intercept, intermesh, interblend, and transact with Vril juncture throughout experiential space. Vril aerial-ground assemblages are most powerful in viscero-eidetic content when both configurations merge with Vril junctures. Special ground-space placements requires the enlistment of old methods (geomantic) for ascertaining favorable locales and station sites (Ward).

Whenever minerals and metals enjoin Vril threads and provide prolific Vril striation contacts and intermeshings we call these "grounds" or "aerials". The archane concept of the aerial viewed the materially projected elevation as cathodes and anodes in space. Vril provides the communal transaction between worlds and districts. When space provides Vril striations in material contacts we call these aerials. Both ground and aerial assemblages are conductive intermeshings and interlinkages amid the Vril matrix. The absolute need for sensitively surrendered and respectful placement of these systems on specific junctures determines the successful entrainment of Vril potentials.

Aerial batteries alter district consciousness. Aerial batteries alter district eidetic content. The primary function of aerial batteries is viscero-eidetic in nature. The use of rheostats in aerial batteries (Palinscar). Eidetic transactions are adjustable. Rheostats permit adjustments in proportional balances between Vril transactivities and inertial reactivities.

Stationary placements of material configurations alter the entire exper transaction of Vril in a region. Bilocational experiences through matter continually reveal singular truths con-

cerning the Vril environmental structure of a region. Continual bilocational visitations to specific eidetic points reveals the existence of powerful Vril centers in fundamental Vril Templates.

Space surrounding such Vril centers is eidetically projected space. The integrity of the apparent world depends on these points. These Vril points suffuse and sustain vitality in the devoid apparent world infra-structure.

Aerial batteries display transmutations. Metals and other components which impact inertial space at high eidetic potentials become suffused with inertial detritus. Detrital bombardment alters matter. Such materials cease functioning with the resilience which they originally displayed. This factor plays a role in the dysfunction of certain radionic devices which have been exposed to a continual barrage in a specific alignment. We often find the need to re-adjust such designs and re-align them. In some occasions we need to replace their "worn parts". Examination shows that such materials have become spongey and osseous in nature.

VRILLIC DETRITUS

Fields, charges, and field-symmetries are the limited rigidified expressions of inertial technology requires the exchange of inertia as a working substance. Inertial rotors concentrate inertial detritus. Inertial technology transforms and exchanges detritus. There are those sensitive persons who are able to see the black waverings which precede earthquakes.

There are those sensitive individuals who are able to feel the uneasy nervous discomfort produced by these close distanced waverings manifestations. These are heat-like waves not unlike the N-rays of Blondlot. Inertial space are dead space. Their origins are mysterious. Sacred writings have described their probable inception. Inertial space cannot resist Vril. Inertial space resist the expansion of Vril eidetic transactions. Inertial space exert constrictive pressures. Vril and its primary manifestations are causative.

Inertial science studies detrital effects and Vril-effected patterns. Such inertial patterns also transfer emotional armor to space. externalized emotional armor acts as a rigid mantle in habitations. These must be broken and dissolved through Vril designs. iron spontaneously dissolves inertial forms. Special iron shapes (cones, helical cones, pyramidal multi-crystals) dissolve inertial space spontaneously and continuously.

Detrital charges are accumulated in the mass of material reservoirs. Detrital charge is the inertial product of eidetic transactions. Such charges have been drained as free-energy (Tesla, Perrigo, Moray, Coler, Hendershot). Detrital formations (electric charges) in materials evidence the continual reactivities of all eidetic transactions among themselves.

Geometric material configurations direct and collimate inertial detritus. Specific minerals, metals, lodes, and grounds dissolve, absorb, shear, and cavitate inertial space in the native states. Iron spontaneously dissolves and eradicates inertial space. Iron poles and towers are excessively viscero-eidetic in transactivity. Human experience is shaped by Vril transactions. We need Vril eidetic transaction. It is living nutrient to our being.

Rapid eye movement sleep is the organismic freeplay which signals deep eidetic transaction. Vril provides free translatory organismic experience. Vril is self-referencing and ever active throughout experiential space. Experiential space is living and transactively communicating among its members. By these transactive depths do organisms find freedom from internalized inertia.

Vril channels are weather alleys. These are natural lanes in which vril channels effect inertial dissolutions with regularity. Inhabitants can predict when weather is going to change because they sense the emerging Vril viscero-eidetic transactivities. Altering district relationships between Vril surface radiance and inertial concentrations alters regional climate and mood through eidetic transaction. It is possible to pass through surrounding storm conditions and pass into regions which evince consistent fair weather patterns. Islands often do this.

Geophysical telluric exploration utilizes the inertio-detrital components which Vril has inadvertently generated in its projection of eidetic worlds. Telluro-electrical currents are projected on Vril eidetic transactive axes. The use of design forms peculiar to those developed by N.Stubblefield are apparent.

Telluro-electric currents have viscero-eidetic content because they are Vril generated. These viscero-eidetic contents must be longitudinally enjoined through appropriate materials. Geophysics never entertains the notion that such signals may themselves be richly intelligent. Signals as eidetic information has been rarely discussed (Hieronymous, Lawrence, Bradford). Ore bodies, lodes, mineral deposits, ground crystals (pegmatites), and crystal caverns project powerful eidetic potentials into the surrounding and supported districts.

Telluro-detrital products are not viscero-eidetic: they are inertial in content. Vril projections are viscero-eidetic intelligent transactions. The true telluric currents are not magnetoelectric; they are Vril dendritic. The true telluric currents cannot be directly measured with meters and inertial tools. The true telluric currents are experiential. Experience cannot be shared, comprehended, or objectified by measurement. Empirical consortium mutually validates such realities.

The true telluric currents are termed "les Woivres" by the ancients who sensed, mapped, and relied upon their life-generating qualities. Vril threadways were called "les woivres" by sensitives who saw, felt and experienced their "merry dance". These were the true telluric currents; capable of enjoining viscero-eidetic experience and transmuting consciousness.

When Vril ground transactions are intercepted up through mountain ores the crystallography of ground act as components of a vast System. Sudden Vril surges effect sudden inertial dissolutions. The resultant inertial shockwaves pass through the deep strata and escape through the surface into the sky. Such effects have been experienced and recorded by credible persons (mountain resonance). The resulting shockwaves may be witnessed as quakings and inertial concentrations (lightning from the ground). The glowing light which follows these inertial dissolutions is pure Vril light; and must not be confused with

electrical activity.

The true telluric currents are not magneto-electric. Neither are they of water or mercury...they are not substantial. True telluric currents are Vrillic and are capable of communicating meanings to us. They are often found surrounded by products which project and generate. Those who envision Vrillic "currents and underground rivers" often mistake them for subterranean watery rivers of glowing, crackling blackness.

To understand what telluric currents truly are we must first understand transactions of Vril. Inertial examinations of detrital flux among dissimilar minerals and metals (across space or in contact) reveals an experiential dual-current effect which occurs in opposed permeating directions (Galvani). This empirical sensation was the origin of the "dual current" theory of electricity. We see that it is empirically determined and is correct; although electricity is not what is being experienced in these cases.

Examinations of this visceral kind do not equal the degree or excellence of eidetic experiences. Examinations based upon visceral examinations alone are not sufficient for predicting what one will eidetically experience when contacting a material configuration. These activities are possessed of another Vril Template (the stratification of experience) when considering charge manufacture and movement between space and ground (Loomis).

Vril eidetic transactions can cause weather reversals. Detrital reversals are often observed in elevated terminals. terminals often precipitate weather change. Actions occurring in an aerial terminal drive the region or district by projecting and collimating eidetic transactions into specific portions of space inertia. Reich re-discovered these realities.

Discoveries have been made which strongly correlate the eidetic content of matter with fundamental activities in the physical environment. The transaction of eidetic experiences taken from configurations of minerals and metals represents a fundamental and primal cause of mechanistic activities.

Eidetic world experiences are pre-inertial and pre-natural. Vril eidetic experience permeates matter. Specific natural Vril eidetic experiences are exceptional after sunset for several hours. Vril channels transact strongly at ground surface during the night.

Vril district junctures self-transact. Vril regions self-reference: a mysterious communications process among created worlds. Toward whom are the mystery Vril thread beams arcing into space? From whose operative activities and intentions are Vril threads arcing into the deeps of upper space?

Weather is not the result of air-mass movement. Weather is the result of mysterious Vril resonance. White rays are highly collimated white fibrils of inertia. Some have erroneously called these "aether" and have engaged attempts to detect drifts in the same (Lodge, Michelson, Morley). Eidetic worlds project the purity of experience which have been called "aura, aether, atmosphere, eloptic, orgone". Eidetic imagery and its experience is the fullness which these indirect descriptions represent.

White rays (ray sheaths) are projected as radiant emissions when intense Vril activity dissolves and cavitates inertial space. The resulting inertial collimations of white fibrils represent vast shears in the inertial space. These white rays (ray sheaths) glow in the sensate illuminations brought through eidetic magnifications. Something of the whole eidetic transaction is diffracted at the inertial shear-site and the pure colors of eidetic worlds may leak through.

Vril activity may also endraw the black ray sheaths (of space-distant Vril matricies) and the white ray sheaths by so shearing space that distal inertial portions rush into the inflection sites as rays. Black rays are highly collimated Vril thread bundles: vascular projections of eidetic experience. Vril activity of specific focussed inflections project black rays (ray threads) across space as experiential discharges. They have as their intent the juncture and proliferation of new experiential quality blends.

Vril surges in matter create new inflections. Unexpected Vril permutations represent pan-regional transmutations of consciousness. The use of Platinum terminals allows lateral straightline rayic transmissions overground (Ward). Platinum reacts with space directly. Platinum aerial terminals Intensified Vril conductivity in platinum dissolves inertia and inertial detritus. The use of iron terminals brings excessive transactivities which modify ground Vril threads.

Vril communicates extraordinary holistic knowledge and experience. Vril communicates and permeates through the human organismic Vril conduits. Vril sensation transmits the sensation of archetypes. Vril sensations and communications transmit socially significant dynamyds. Vril messages activate, mutate, and sustain civilization.

Inertial detritus is material specific. Inertia erases emotions and senses. Inertia limits, rigidifies, resists, and distorts true experience. Specific eidetic reactions produce inertial shockwaves of specific sense-distorting and sense-blocking ability.

Careful arrangements of materials can reduce and eliminate such inertial shockwaves and their detrital products. Careful arrangements of specific materials release Vril potentials which overcome the human organism through Vril conductions. Vril technology is the determined effort to create humanly valuable Vril reactions. Vril technology has as its goal the magnification of Vril experience. Vril experience is maximum human experience.

Kilner's study of aurae and haloes did not include the self-luminous aurae which Reichenbach examined. Kilner's study required inertial illuminations of condensations. It is significant that Kilner did not describe transactional and translational eidetic experiences; although in truth each organismic participant freely engages in such translatory experiences. Inertial science refers to these phenomena as "mental wanderings" and "daydreams".

Self-interacting Vril threadways discharge among Vril juncture points throughout the infra-structure of this apparent world. In absence of direct eidetic experience we detect appearance of various ray sheaths across ground, from ground to space, among distal space-points, from space to ground, and among deep subterranean junctures. The black radiance of space is the Vril projected space aura.

The Vril impact of inertial space produces detrital expres-

sions. Detrital expressions are resisted Vril expressions: the highly inertial refuse observed as material droplets, charges, particles, fields, patterns, polarizations, symmetrizations, ponderomotive movements, fluxions, currents, oscillations, impulses... all the effects which inertial science collates and erroneously calls primary.

Leylines are inertial white raysheaths. They coincide with Vril natural threadways. The white inertial sheaths themselves are detrital currents. Inertial Science measures, maps, and charts dynamic changes in "telluric currents" on the basis of magneto-electric parameters alone.

Vril is true living energy.

Vril eidetic inter-communications utilize self-differentiating, self-collimating, self-directional Vril thread connections; whereby specific eidetic transactions remain distinct and capable of self-organization.

Visceral omni-sensation occurs during specific eidetic transactions. The sense of "what happens there...happens here" typifies this transactive sense.

Vrillic bilocational experience represents action at a distance where no connectivity or interstitial travel exists for the participant. Ghostly activities are often caused by such sudden transactions.

Inertio-detrital effects occur when visceral experiences exceed eidetic experiences. Zinc-carbon combinations produce strong visceral sensations in absence of strong eidetic sensations. Strong duo-current visceral experience is noted in certain dissimilar metallic assemblies.Contact with zinc or carbon brings a sense of "push-pull" activity. This sensation is translated into the electro-detrital activity observed and measured in those systems. It is possible to configure minerals and metals for the strict magnification of inertio-detrital alone in absence of eidetic translation.

The presence of Vril threads generate telluric magneto-electric detritus. Magneto-electric detritus is a sustained Vril-generated pattern observed throughout special zones of the apparent world. This is why charge and magnetism is sustained in the world.

Spontaneous Vril eidetic surges are self-examinations in absence of participants: Vril self-examines itself. Vril eidetic worlds engage in free trans-mergings. Vril self-examinations generate magneto-electric manifestations. Such patterns are called "telluric" by inertial science. Impacted inertia manifests detritus in surficial and visceral experience.Vril thread passage across faultlines releases detritus. This has been observed as "telluro-electrical stresses with charge-transfer".

Faultlines are sites where metals, minerals, and crystals are generated. Vril impacted inertia generates "shudderings", earthquakes, mountain bourdonnements. Lacking willingness to experience viscero-eidetic sensations, Inertial science measures mere patterns generated with natural Vril engages in spontaneous eidetic surges. Vril penetrates inertial strata.

Radiant Vril aurae signal spontaneous eidetic world transmergings.

Vril is eideto-radiant in non-inertial spaces.

Eidetic transactions do not occur when organismic auric contact is misaligned. Eidetic transactions only occur in alignments where the participants can be merged directly with the arcing Vril discharges emanating from an active site. There are places where eidetic experiences are disturbed and distorted by regional disruptions. These must be re-configured by Vril Technology.

Natural minerals and metals whose surficial appearance is white are minerals and metals which release strong concentrations of inertial detritus.

Objects which appear dark are minerals and metals which are highly Vril conductive. Black minerals and other such substances (under organismic examination) release a misty white inertial effluence. Organismic examinations project Vril threads into such minerals and metals with the resulting misty white detrital appearance.

Elements and substances may be classified according to groupings of either black (Vril conductivity) or white (inertial resistivity). Strong dark minerals and substances strongly conduct Vril each with various proportions of resultant inertio-reactive effluence.

Viscero-visual sightings of black raysheaths and white raysheaths are found to be composed of intensely collimated Vril thread wrigglings having specific activity on the inertial spaces which they transpierce.

Decisive experimentation in the examination of inertial detritus (dark/white minerals) must proceed with eyes closed in darkened rooms. Contact with such minerals releases inertial effluence when contacted organismically. Dark objects are not as inertially productive as white minerals.

Reflective metal surfaces offer some inertial resistances to the probings of organismically projected Vril threads. Spatially disposed assemblies of dissimilar metals and minerals provide visceral experiences of dual currents. Such currents are simultaneously opposed passages of Vril and inertial. of various proportions. All substances are simultaneously (proportionally) Vril-conductive and inertial-resistive.

Organismic Vril sensory systems do not easily participate in volumes of high inertial concentration. Dark objects provide easier Vril transaction from organism to object. Organismo-visceral responses of reflective metals vary. Iron is highly vril thread absorptive. It is the Vril metal.

Inertial detritus is strongly absorbed, and distorted away from the entire organismic presence when near or in contact with Iron. Iron contacts prove to form organismic conical shields.

Light organic minerals and metals conduct Vril and permit visceral transaction while constantly emanating a mild and resistive white inertial effluence. Natural minerals and metals may be color grouped when studying inertio-detrital reactivities under Vril impact. The natural occurrence of minerals, and geological minerals and metals (crystals, gems, lodes) is a study which requires experience with Vril auric projections.

The eidetic content of all naturally occurring minerals and metals which are the organismically meaningful and valuable contents. Coloration and surficial appearance of minerals, lodes, and other naturally occurring minerals and metals provides information of inertial reactivities only.

We must empirically examine natural substances to

discover the true foundations of inertial reactivities and visceral attributes. White minerals and white stony substances produce prolific amounts of inertial detritus which offer organismic resistance. Black minerals and metals provide various increased degrees of viscero-eidetic conductivity. Between the two groupings (black and white) we discover fixed proportions which may be charted.

Eidetic world projections through materials is spontaneous in absence of organismic contact or intent" nature is examining itself.

Eidetic world projections release inertial effluences through inertial space impacts. All minerals and metals are Vril transaction sites.

We gradually acquire knowledge concerning eidetic fundamentals. One learns the viscero-eidetic content of isolated matter, material configurations, and (ultimately) the holisms of natural settings. The appreciation and wonderment finally obtained in eidetically transacting with holistic natural settings reveals and demands the astonishing reality of divine ordination and divine plan.

Eidetic transactions prove to be native phenomena utilized by Vril technology. Vril technology is simple; requiring knowledge only of Vril natively available transactions. Eidetic worlds project the purity of experiences which have been called "aura, aether, atmosphere, eloptic, orgone". The inertial manifestations of eidetic projections are observed as coronae and haloes (Tesla, Kilner).

White rays (ray sheaths) are projected as radiant emissions when intense Vril activity dissolves and cavitates inertial space. The resulting inertial collimations of white fibrils represent vast shears in the inertial space. During such intervals regions experience "aurorae...regional magnetic disturbances". These white rays (ray sheaths) glow in the sensate illuminations brought through eidetic magnifications.

Something of the whole eidetic transaction is diffracted at the inertial shear-site and the pure colors of eidetic worlds may leak through. Vril activity may also endraw the black ray sheaths (of space-distant Vril matricies) and the white ray sheaths by so shearing space that distal inertial portions rush into the inflection sites as rays.

Black rays are highly collimated Vril thread bundles: vascular projections of eidetic experience. Vril activity of specific focussed inflections project black rays (ray threads) across space as experiential discharges. They have as their intent the juncture and proliferation of new experiential quality blends.

The deepest Vril Template generates, sustains, and projects the eidetic worlds which are experienced. Vril is the glowing blackness from which emerge experiences. Vril is the black radiance in which eidetic contents are received. Vril black radiances emanate all worlds. Vril transects the inertio-physical complex.

Vril threads affect the nerves of the human organism through synaptic engagements. Vril threads affect the sensory system in absolute blackness. Vril eidetic content is spontaneous and whole. The experience of Vril threads require none of the 5-sensors. Grounded materials manifest powerful Vril generated qualities. Aerial (disconnected) materials do not manifest strong Vril qualities. Grounded examinations of materials release strong degrees of experiential penetrations. Vril activated materials require specific orientations along known Vril channels. Choice of deepest Vril channels is demanded.

Vril activated materials affect specific viscero-eidetic portions of the human organism. The sensory body we experience depends upon the eidetic world we experience. Vril activated materials reveal Vril connectivities in the human organism. Vril is the glowing blackness from which emerge experiences. Vril is the black radiance in which eidetic contents are received. Vril black radiances emanate all worlds. Vril activated materials instantly effect specific eidetic transactions which become the experiential space.

Inertial science tracks the passage of "electrical charge" through all "conductive minerals and metals" in reductionistic fashion. Inertial science assumes that common conductivity of a singular essence or influence (charges, fields) infers the fundamental reality of such transfer.

Earthquakes are Vril reactions. Earthquakes are inertial responses to eidetic world transmergings. Earthquakes release detrital components. Danger results when Vril reaction geometries and matter is misconfigured.

Lunar eclipses and other celestial configurations effect specific misproportional inertial products across vast regions of ground. Vril values are suppressed during such events in specific districts. These effects are entirely die to emerging concentrations of inertial detritus in which organismic participations are effectively suppressed.

Viscero-thrombic pulsations have been experienced along regional main Vril channels. Viscero-thrombic processions have been irregularly observed to follow specific tempi. Minerals and metals which are provided with free-mobility demonstrate remarkable spontaneous spatial re-alignment when eidetic transactions surge. This is the cause of "furtive actions" in auric vanes and dialettes.

Vril Science studies and focusses upon eidetic world experiences before physical attributes. Vril eidetic world activities impact and cause all observed world-inertial effects. Vril eidetic vision extends throughout the Vril landscape. Sensitives know the axially determined experience-lines through which regions may be consciously examined, experienced, and occupied. Thus regions are also remarkably able to present various aspects of the persona from which they derive.

The viscero- eidetic superiority of specific skyscrapers occurs when haphazard ground foundation and aerial projection link naturally occurring Vril nodes throughout the building axis (Chrysler Building). Such vertical Vril node distributions are rare. Vril threads generate, project, sustain, and influence geological forms. Inertial detrital discharges follow Vrillic patterns (lightning). Water channels and courses follow and cooperate with Vril energetic ground patterns.

The metals prove the independent existent of their parent eidetic worlds. We can arrange the existence of the projective worlds in eidetic reactions and blends.Metals are inertial agglumerations which densify their eidetic world qualities.

Copper is projected from a world which is not copper colored: one which is green, yellow, and full of sunshine and green vegetation. Through copper come all the visceral sensual experiences in our world.

Interception of eidetic information channels requires specific metals and minerals. Special accumulators, capacitors (ground connected), tuning devices, and contact mediators are needed for the successful design of eidetic transactors.

Apparent reality can be distorted and warped. Eidetic imagery and experience teaches that world-experience is not a fixed rigidity. Eidetic experiences warp meaningful world-experience. Vril threads and threadways occur on the ground surface. Vril channels are found in the ground geology at depths not exceeding several hundred yards. Vril causeways are the vast regional axes which generate and sustain whole regions.

Specific Vril eidetic worlds release regional memories, facts, and revelatory knowledge. Specific Vril material configurations permit the experience of timeless travel among eidetic worlds. Vril operators conduct excessive degrees of revelatory knowledge. Vril designers and Vril Scientists take especial regard to vril mergings and blendings within Vril systems.
Vril designers must track Vril paths from organismic contacts with minerals and metals, through material masses, and down into the eidetic world foundations.

Vril mergings are continuous; and may be tracked. Vril focussed awareness on Vril insensate generates perceivable spontaneous activity. Organismic Vril mergings generate spontaneous Vrillic activities. Vril thread dynamics seem to proceed in deranged and mysterious expressions. The observation of this strange Vril thread language does not enjoin the examiner with an eidetic experience. Touch contact may quench the activity of certain Vril transactors: gaps are required. Vril energy in gaps often increases with increasing distance from a design. Vril progressively enters the sensate and impacts the inertial.

The eidetic worlds are set and fixed among their numbers. Though the detrital hills may dissolve yet these Vril World mountains and peaks remain. Archeforms and crystallographic pyramidals are the peaks of vast Vril topographies which are viscero-eidetic and whose foundations are timelessly ancient. This topography is quasi-material. This topography connects with the stars.

White inertial sheaths bring perceptual congestions, distortions, and organismic difficulties. The enjoinment and concentration of inertial detritus must be avoided. Inertia is fibrillic when concentrated. White inertial fibrils are dangerous to organismic integrity. White rays are highly collimated white fibrils of inertia. White inertial presence rises through the surface of daylit earth.

Vril projections release Vril Light into the inertial space. These have been observed. Vril Light is pure Light. Galvanic metallo-configurations are Vril transactors. Vril Light appears in specific metal and mineral configurations (ground and apparatus). Devices may entune the manifestation of Vril Light. Special materials are Vril Light stones. Pure Vril Light is organismically vitalizing. Vril light is formative radiance. Vril light does not destroy its conductors. Vril light is phosphorescent in densified inertio-detrital spaces. Certain diffractors arrange Vril phosphorescence (Plucker, Crookes, Tesla, Mac Farland-Moore).

Chemical reactions are Vril projected transactions. Chemical detritus appears as compounds of projected matter chemical reactions are eidetic. Chemical detritus contains viscero-eidetic complexes. Projected metals and crystals may not mutually diffuse. Vril eidetic transactions among lodes, crystals, and mineral project eidetic materials among the projective masses.

Vril aurae are tufted striations. Specific Vril aurae contain pro-generative inflections during specific times. Inertially empowered glowing haloes expand Vril aureoles. Electrical activations expand aurae (Reichenbach, Starr-White, Tesla, Kilner). Forced electro-impulses greatly expand the aura (Tesla).

Vril can release luminescence (Stubblefield, Moray, Tesla). Ancient legends tell of special glowing stones whose radiance was like blazing sunlight...at midnight. Vril Light is organismically magnified. Vril Light may not be inertially radiant; affecting organismic participants.

Inertia produces endlessly meaningless patterns. Sensitives follow these patterns in search of the causative Vril threadways which provoke their disturbed appearance.

Vril thread contacts envelop participants in communions. White radiant displays designate Vril dissolution and radiation of inertial space. Black radiant displays designate Vril dissolution and absorption of inertial space.
Vril responds to humanly arranged inertial interruptions for greater purpose. This Vril Law of sustenance is not mechanistic in action. Vril is personable. Vril intent matches and surpasses inertial presence to preserve organismic regional integrity. Vril projects generativity and sustains worlds.

SECTION 2

LIGHTNING RODS

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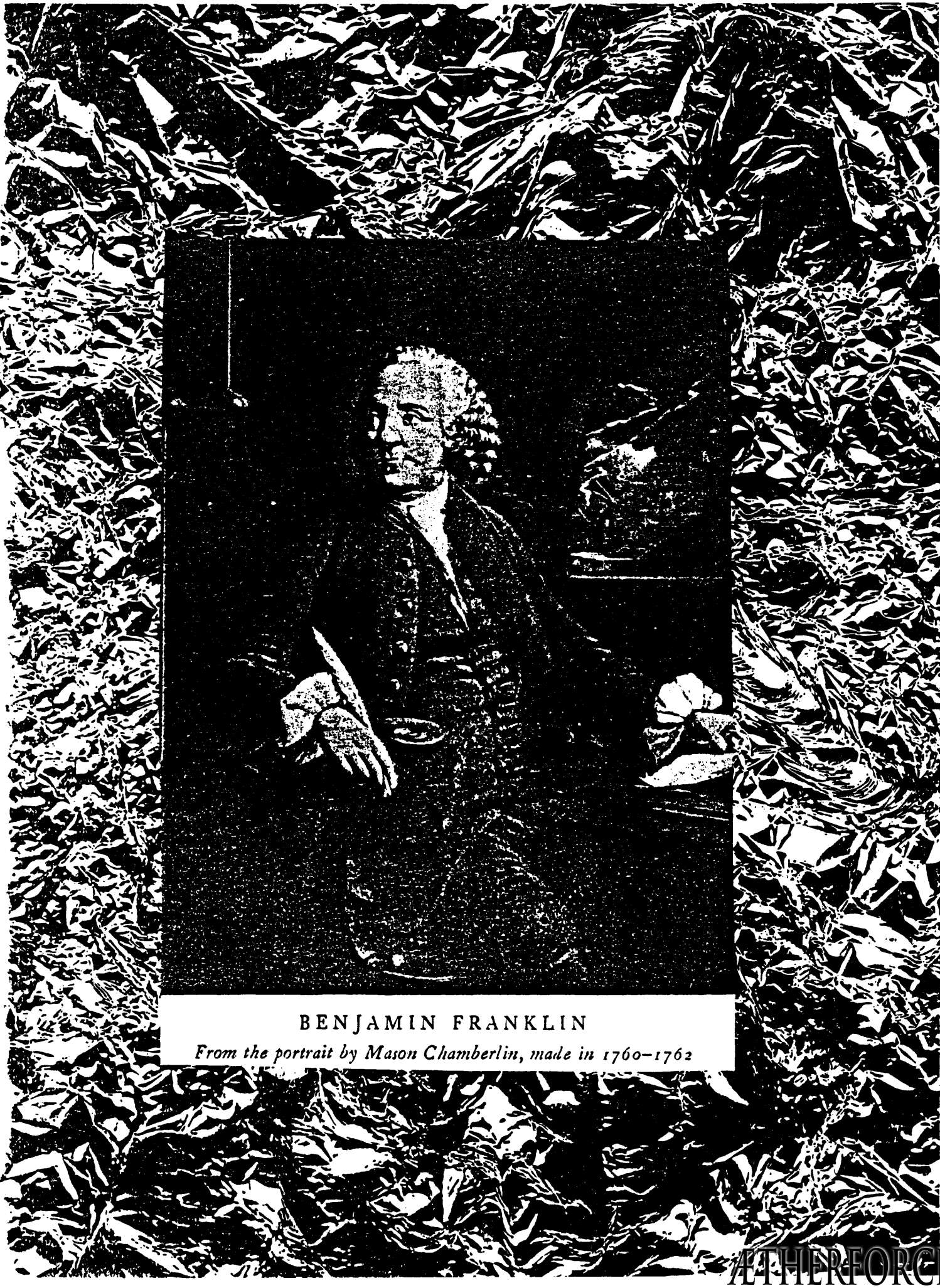

BENJAMIN FRANKLIN

From the portrait by Mason Chamberlin, made in 1760–1762

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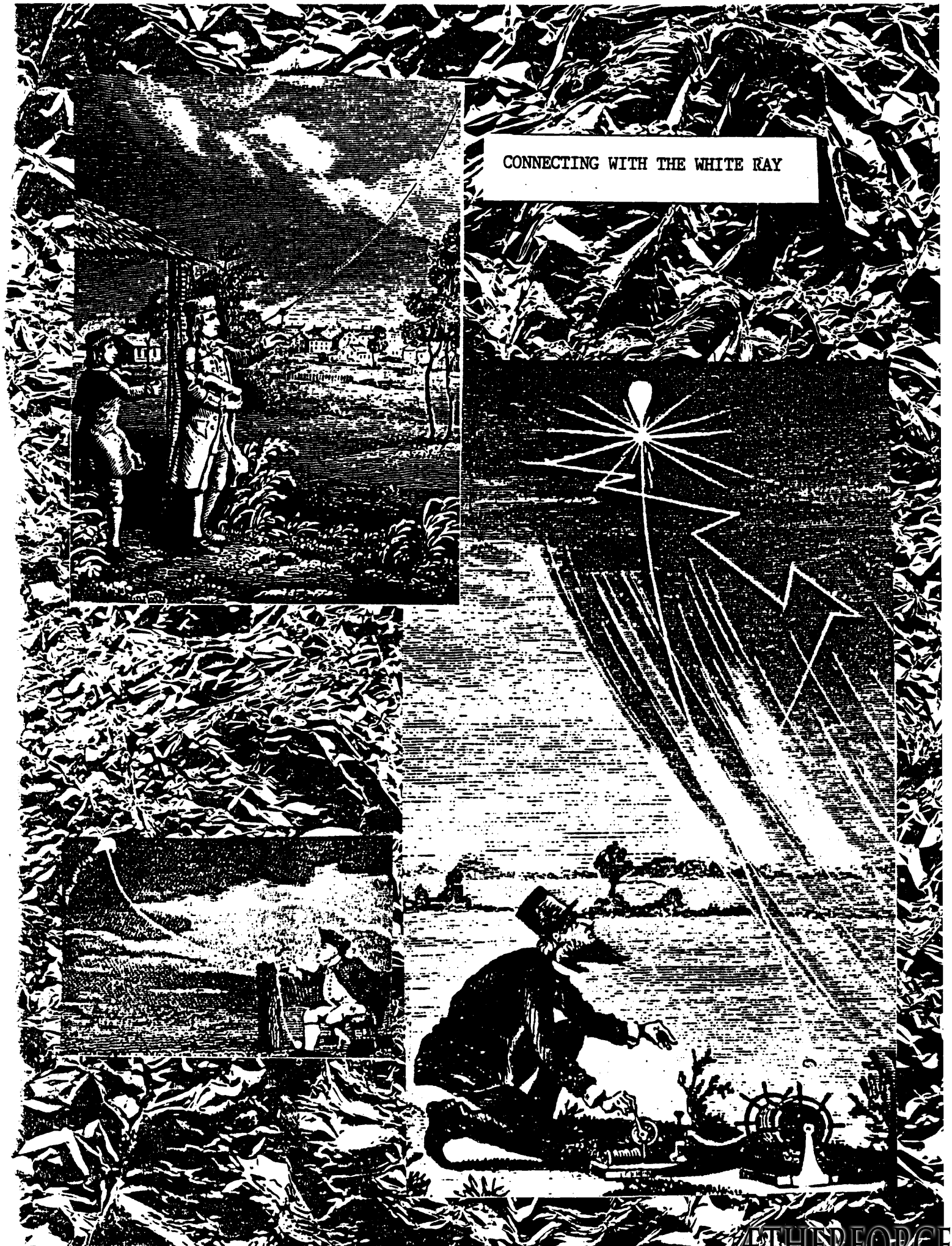

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XXXI. *An Account of Mr.* Benjamin Franklin's *Treatiſe, lately publiſhed, intituled,* Experiments and Obſervations on Electricity, made at Philadelphia in America; *by* Wm. Watſon, *F. R. S.*

Read June 6. 1751.

MR. Franklin's treatiſe, lately preſented to the Royal Society, conſiſts of four letters to his correſpondent in England, and of another

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other part intituled "Opinions and conjectures concerning the properties and effects of the electrical matter ariſing from experiments and obſervations."

The four letters, the laſt of which contains a new hypotheſis for explaining the ſeveral phænomena of thunder-guſts, have either in the whole or in part been before communicated to the Royal Society. It remains therefore, that I now only lay before the Society an account of the latter part of this treatiſe, as well as that of a letter intended to be added thereto by the author, but which arrived too late for publication with it, and was therefore communicated to the Society by our worthy brother Mr. Peter Collinſon.

This ingenious author, from a great variety of curious and well-adapted experiments, is of opinion, that the electrical matter conſiſts of particles extremely ſubtil; ſince it can permeate common matter, even the denſeſt metals, with ſuch eaſe and freedom, as not to receive any perceptible reſiſtance: and that if any one ſhould doubt, whether the electrical matter paſſes through the ſubſtance of bodies, or only over and along their ſurfaces, a ſhock from an electrified large glaſs jar, taken through his own body, will probably convince him.

Electrical matter, according to our author, differs from common matter in this, that the parts of the latter mutually attract, and thoſe of the former mutually repel, each other; hence the divergency in a ſtream of electrified effluvia §: but that, tho' the particles

§ As the electric ſtream is obſerved to diverge very little, when the experiment is made *in vacuo*, this appearance is more owing

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particles of electrical matter do repel each other, they are ſtrongly attracted by all other matter.

From theſe three things, *viz.* the extreme ſubtilty of the electrical matter, the mutual repulſion of its parts, and the ſtrong attraction between them and other matter, ariſes this effect, that when a quantity of electrical matter is applied to a maſs of common matter of any bigneſs or length within our obſervation (which has not already got its quantity) it is immediately and equally diffuſed thro' the whole.

Thus common matter is a kind of ſponge to the electrical fluid; and as a ſponge would receive no water, if the parts of water were not ſmaller than the pores of the ſponge; and even then but ſlowly, if there was not a mutual attraction between thoſe parts and the parts of the ſponge; and would ſtill imbibe it faſter, if the mutual attraction among the parts of the water did not impede, ſome force being required to ſeparate them; and faſteſt, if, inſtead of attraction, there were a mutual repulſion among thoſe parts, which would act in conjunction with the attraction of the ſponge: ſo is the caſe between the electrical and common matter. In common matter indeed there is generally as much of the electrical as it will contain within its ſubſtance: if more is added, it lies without upon the ſurface ‖, and forms what we call an electrical atmoſphere; and then the body is ſaid to be electrified.

'Tis ſuppoſed, that all kinds of common matter do not attract and retain the electrical with equal force, for reaſons to be given hereafter; and that thoſe called electrics *per ſe*, as glaſs, *&c.* attract and retain it the ſtrongeſt, and contain the greateſt quantity.

We know, that the electrical fluid is in common matter, becauſe we can pump it out by the globe or tube; and that common matter has near as much as it can contain; becauſe, when we add a little more to any portion of it, the additional quantity does not enter, but forms an electrical atmoſphere: and we know, that common matter has not (generally) more than it can contain; otherwiſe all looſe portions of it would repel each other, as they conſtantly do when they have electric atmoſpheres.

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to the reſiſtance of the atmoſphere, than to any natural tendency in the electricity itſelf. *W. W.*

‖ The author of this account is of opinion, that what is here added, lies not only without upon the ſurface, but penetrates with the ſame degree of denſity the whole maſs of common matter, upon which it is directed.

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The form of the electrical atmoſphere is that of the body, which it ſurrounds. This ſhape may be render'd viſible in a ſtill air, by raiſing a ſmoke from dry reſin dropp'd into a hot tea ſpoon under the electriſed body, which will be attracted and ſpread itſelf equally on all ſides, covering and concealing the body. And this form it takes, becauſe it is attracted by all parts of the ſurface of the body, though it cannot enter the ſubſtance already replete. Without this attraction it would not remain round the body, but be diſſipated in the air.

The atmoſphere of electrical particles ſurrounding an electrified ſphere is not more diſpoſed to leave it, or more eaſily drawn off from any one part of the ſphere than from another, becauſe it is equally attracted by every part. But that is not the caſe with bodies of any other figure. From a cube it is more eaſily drawn at the corners than at the plane ſides, and ſo from the angles of a body of any other form, and ſtill moſt eaſily from the angle that is moſt acute; and for this reaſon points have a property of drawing on, as well as throwing off the electrical fluid, at greater diſtances than blunt bodies can.

From various experiments recited in our author's treatiſe, to which the curious may have recourſe, the preceding obſervations are deduced. You will obſerve how much they coincide with and ſupport thoſe which I ſome time ſince communicated to the Society upon the ſame ſubject.

To give even the ſhorteſt account of all the experiments contained in Mr. Franklin's book, would exceed greatly the time allowed for theſe purpoſes by the Royal Society: I ſhall content myſelf therefore with laying a few of the moſt ſingular ones before you.

The effects of lightning, and thoſe of electricity, appear very ſimilar. Lightning has often been known to ſtrike people blind. A pigeon, ſtruck dead to appearance by the electrical ſhock, recovering life, drooped ſeveral days, eat nothing, tho' crumbs were thrown to it, but declined and died. Mr. Franklin did not think of its being deprived of ſight; but afterwards a pullet, ſtruck dead in like manner, being recovered by repeatedly blowing into its lungs, when ſet down on the floor, ran headlong againſt the wall, and on examination appeared perfectly blind: hence he concluded, that the pigeon alſo had been abſolutely blinded by the ſhock. From this obſervation we ſhould be extremely cautious, how in electriſing we draw

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draw the ſtrokes, eſpecially in making the experiment of Leyden, from the eyes, or even from the parts near them.

Some time ſince it was imagined, that deafneſs had been relieved by electriſing the patient, by drawing the ſnaps from the ears, and by making him undergo the electrical commotion in the ſame manner. If hereafter this remedy ſhould be fantaſtically applied to the eyes in this manner to reſtore dimneſs of ſight, I ſhould not wonder, if perfect blindneſs were the conſequence of the experiment.

By a very ingenious experiment our author endeavours to evince the impoſſibility of ſucceſs, in the experiments propoſed by others of drawing forth the effluvia of non-electrics, cinamon, for inſtance, and by mixing them with the electrical fluid, to convey them with that into a perſon electrified: and our author thinks, that tho' the effluvia of cinamon and the electrical fluid ſhould mix within the globe, they would never come out together through the pores of the glaſs, and thus be conveyed to the prime conductor; for he thinks, that the electrical fluid itſelf cannot come through, and that the prime conductor is always ſupplied from the cuſhion, and this laſt from the floor. Beſides, when the globe is filled with cinamon, or other non-electrics, no electricity can be obtained from its outer ſurface, for the reaſons before laid down. He has tried another way, which he thought more likely to obtain a mixture of the electrical and other effluvia together, if ſuch a mixture had been poſſible. He placed a glaſs plate under his cuſhion, to cut off the communication between the cuſhion and the floor: he then brought a ſmall chain from the cuſhion into a glaſs of oil of turpentine, and carried another chain from the oil of turpentine to the floor, taking care, that the chain from the cuſhion to the glaſs touched no part of the frame of the machine. Another chain was fixed to the prime conductor, and held in the hand of a perſon to be electrified. The ends of the two chains in the glaſs were near an inch from each other, the oil of turpentine between. Now the globe being turned could draw no fire from the floor through the machine, the communication that way being cut off by the thick glaſs plate under the cuſhion: it muſt then draw it through the chains, whoſe ends were dipp'd in the oil of turpentine.

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And as the oil of turpentine being in ſome degree an electric *per ſe*, would not conduct what came up from the floor, the electricity was obliged to jump from the end of one chain to the end of the other, which he could ſee in large ſparks; and thus it had a fair opportunity of ſeizing of the fineſt particles of the oil in its paſſage, and carrying them off with it: but no ſuch effect followed, nor could he perceive the leaſt difference in the ſmell of the electrical effluvia thus collected, from what it had when collected otherwiſe; nor does it otherwiſe affect the body of the perſon electrified. He likewiſe put into a phial, inſtead of water, a ſtrong purging liquid, and then charged the phial, and took repeated ſhocks from it; in which caſe every particle of the electrical fluid muſt, before it went through his body, have firſt gone thro' the liquid, when the phial is charging, and returned through it when diſcharging; yet no other effect followed than if the phial had been charged with water.

He has alſo ſmelt the electrical fire, when drawn thro' gold, ſilver, copper, lead, iron, wood, and the human body, and could perceive no difference; the odour being always the ſame, where the ſpark does not burn what it ſtrikes; and therefore he imagines, that it does not take that ſmell from any quality of the bodies it paſſes through. There was no abridging this experiment, which I think very well conceived, and as well conducted, in a manner to make it intelligible; and therefore I have laid the author's words nearly before you.

As Mr. Franklin, in a letter to Mr. Collinſon ſome time ſince, mentioned his intending to try the power of a very ſtrong electrical ſhock upon a turkey, I deſired Mr. Collinſon to let Mr. Franklin know, that I ſhould be glad to be acquainted with the reſult of that experiment. He accordingly has been ſo very obliging as to ſend an account of it, which is to the following purpoſe. He made firſt ſeveral experiments on fowls, and found, that two large thin glaſs jars gilt, holding each about 6 gallons, and ſuch as I mentioned I had employed in the laſt paper I laid before you upon this ſubject, were ſufficient, when fully charged, to kill common hens outright; but the turkeys, though thrown into violent convulſions, and then, lying as dead for ſome minutes, would recover in leſs than a quarter of an hour. However, having added three other ſuch to the former two, though not fully charged, he killed a turkey of about ten pounds weight, and believes that they would have killed a much larger. He conceited, as himſelf ſays, that the birds kill'd in this manner eat uncommonly

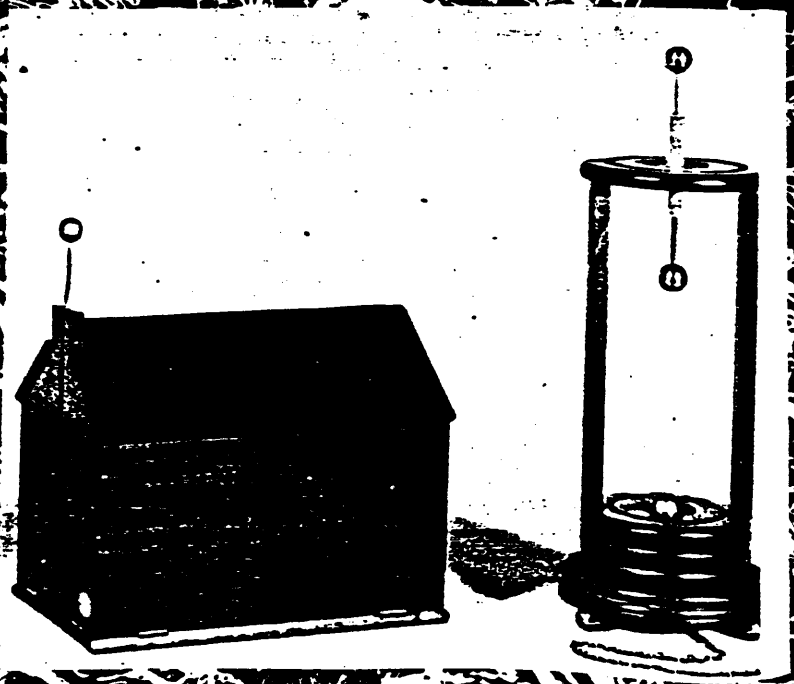
ÆTHERFORCE

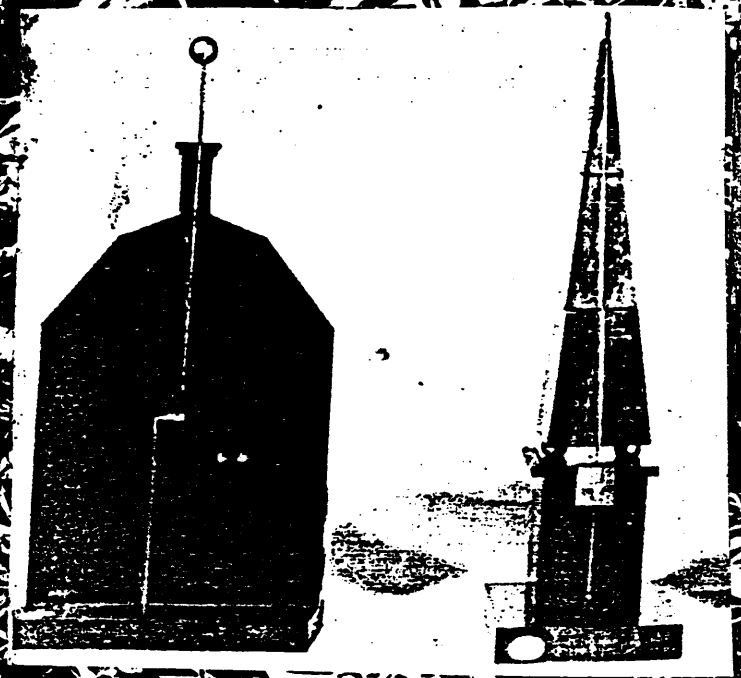
In making theſe experiments, he found, that a man could, without great detriment, bear a much greater ſhock than he imagined: for he inadvertently received the ſtroke of two of theſe jars through his arms and body, when they were very near fully charged. It ſeemed to him an univerſal blow throughout the body from head to foot, and was followed by a violent quick trembling in the trunk, which went gradually off in a few ſeconds. It was ſome minutes before he could recollect his thoughts, ſo as to know what was the matter; for he did not ſee the flaſh, tho' his eye was on the ſpot of the prime conductor, from whence it ſtruck the back of his hand; nor did he hear the crack, tho' the byſtanders ſaid it was a loud one; nor did he particularly feel the ſtroke on his hand, tho' he afterwards found it had raiſed a ſwelling there of the bigneſs of half a ſwan-ſhot, or piſtol-bullet. His arms and the back of his neck felt ſomewhat numbed the remainder of the evening, and his breaſt was ſore for a week after, as if it had been bruiſed. From this experiment may be ſeen the danger, even under the greateſt caution, to the operator, when making theſe experiments with large jars; for it is not to be doubted, but that ſeveral of theſe fully charged would as certainly, by increaſing them, in proportion to the ſize, kill a man, as they before did the turkey.

Upon the whole, Mr. Franklin appears in the work before us to be a very able and ingenious man; that he has a head to conceive, and a hand to carry into execution, whatever he thinks may conduce to enlighten the ſubject-matter, of which he is treating: and altho' there are in this work ſome few opinions, in which I cannot perfectly agree with him, I think ſcarce any body is better acquainted with the ſubject of electricity than himſelf.

ÆTHERFORCE

BELOW: *These wooden models, equipped with lightning rods, demonstrated how Franklin's popular invention made houses and churches safer during electrical storms.*





AETHERFORCE

Jan. 29. Nine o'clock, A. M. a very thick fog, and ſharp froſt. The air is ſo ſtrongly electrified *poſitively*, that the balls ſeparate *full an inch and a quarter*. There is little or no wind, and they remain ſtationary; ſo that the experiment may be made without the leaſt danger of a miſtake.

Twelve o'clock, the balls diverge as wide as at nine.

Three o'clock, P. M. the balls are exceedingly diſturbed by the wind; but, blow as it will, they ſtill keep at a great diſtance from each other. It freezes very hard. A quarter paſt four: the ſame as at three o'clock.

Half paſt five. The balls are ſtationary, *at three quarters of an inch diſtance, from each other*. The fog increaſes; and the rods are perfectly wet, from end to end. It is now too dark for further accurate obſervation.

Jan. 30. Nine o'clock, A. M. I find the air ſtrongly electrified *poſitively*, in a ſlight froſt, and thick fog. The balls ſeparate full half an inch: they are diſturbed by the wind; but it does not cloſe them; and the experiment is tried eaſily. There hath been a ſmall ſhower of ſnow, which lies thinly ſpread upon the houſes; and I have often ſuſpected (as I do now), that *this forms points*, and conducts the electricity faſter. The electricity continued the whole day.

Feb. 4. Nine o'clock, A. M. A ſharp froſt, and thick fog. The air is ſtrongly electrified *poſitively*: the balls diverge full three quarters of an inch. Eleven o'clock, A. M. The balls are ſtationary, *at upwards of an inch diſtance*. They cloſe at the approach of excited wax.

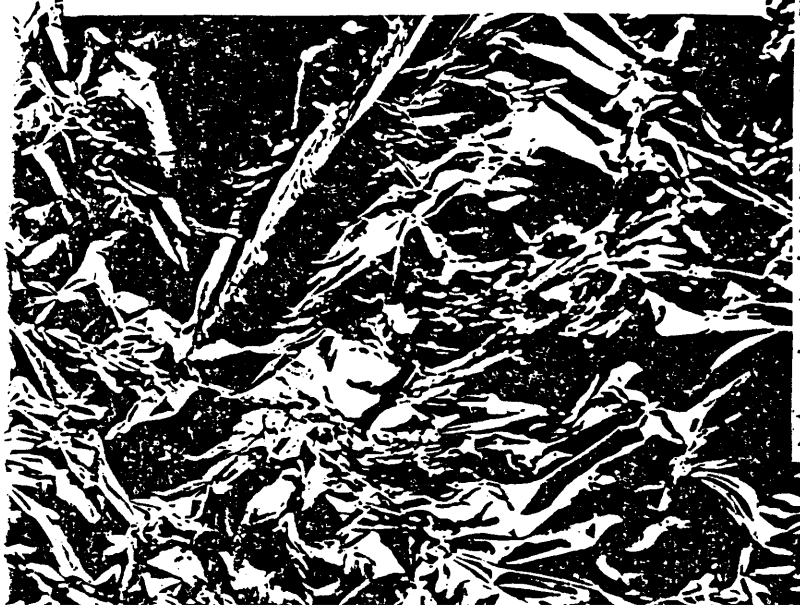
Half paſt two, P. M. The ſame as at eleven o'clock. Three o'clock. Over-caſt and cloudy: the balls are very ſtill, but ſhew ſcarce any ſign of electricity.

Feb. 11. Eight o'clock, A. M. A thick fog is ſenſibly electrified *poſitively*. The balls diverge a quarter, or three eighths, of an inch. Wind S. W. and troubleſome. Thermometer 38. Barometer, 29,94.

Feb. 15. Half paſt ten, A. M. I find a thick fog, ſenſibly electrical. The balls diverge five-eighths of an inch, full. Preſently, after I had fixed my rod, there fell ſome ſmall drops of rain. *Upon the moment of its falling*, the balls increaſed their divergence near, or quite, a quarter of an inch. I never ſaw a fog more ſtrongly electrified when the weather was ſo warm, the mercury in my thermometer, in the open air, being ſeven and an half degrees above the freezing point. I ſuppoſe *higher in the atmoſphere* it is now uncommonly cold.

Fifty minutes paſt two, P. M. It ſnows very faſt. The air is now ſtrongly electrified *poſitively*. The balls ſeparate full three quarters of an inch. Wind S. W.

From the ſmall number of experiments I have been able to make, on the electricity of the atmoſphere, I cannot help being of opinion, that fogs are much more ſtrongly electrified *in*, or *immediately after*, *a froſt*, than at other times; and that the electricity in the fogs is often the ſtrongeſt.



INERTIAL CHARGE THROUGH WHITE RAY REACTORS

AETHERFORCE

XXXVII. *An Account of a Storm of Lightning obſerved on the 1ſt of March, 1774, near* Wakefield, *in* Yorkſhire, *by Mr.* Nicholſon, *Teacher of Mathematics in* Wakefield. *Communicated by Dr.* Prieſtley.

TO THE REV. DR. HORSLEY, SEC. R. S.

DEAR SIR,

Reade, April 14, 1774. THE following account of a ſtorm of lightning was communicated to me by the obſerver Mr. NICHOLSON teacher of mathematics in Wakefield, who is a very ingenious man, and a good electrician. I have no doubt of his having given proper attention to the phænomena which he has mentioned, or of his exactneſs and fidelity in deſcribing them. Some of the circumſtances appear to me to be very extraordinary; and, as far as I know, quite new, not having been noticed by any writer that I have met with; I therefore think it very proper that the account of them be communicated to the Royal Society.

I am, DEAR SIR,

Your very humble ſervant,

JOSEPH PRIESTLEY.

ON

AURORAS AND LIGHTNING STORMS

ON the 1ſt of March, about half an hour paſt ſix in the evening, as I was returning from CROFTON, a village near WAKEFIELD, I ſaw, in the north-weſt, a ſtorm approaching; the wind, which had been ſtrong all the day, ſetting from the ſame quarter; and, as in the afternoon of the ſame day, there had been ſome violent ſhowers of hail, I made the beſt of my way to the turnpike at Agbridge. The air was ſo much darkened, before the ſtorm began, that it was with difficulty I found my way.

When I was about three hundred yards from the turnpike, the ſtorm began; when I was agreeably ſurprized with obſerving a flame of light, dancing on each ear of the horſe that I rode, and ſeveral others much brighter on the end of my ſtick, which was armed with a ferule of braſs, but notched with uſing. Theſe appearances continued till I reached the turnpike-houſe, where I took ſhelter.

Preſently after, there came up five or ſix graziers, whom I had paſſed on the road. They had all ſeen the appearance, and were much aſtoniſhed. One of them, in particular, called for a candle, to examine his horſe's head, ſaying, "It had been all on fire, "and muſt certainly be ſinged."

After having continued about twenty minutes, the ſtorm abated, and the clouds divided, leaving the northern region very clear; except that, about ten degrees high, there was a thick cloud, which ſeemed to throw out large and exceedingly beautiful ſtreams of light, reſembling an *Aurora Borealis*, towards another cloud that was paſſing over it; and, every now and then, there appeared to fall to it ſuch meteors as are called *falling ſtars*. Theſe appearances continued till I came to Wakefield; but no thunder was heard.

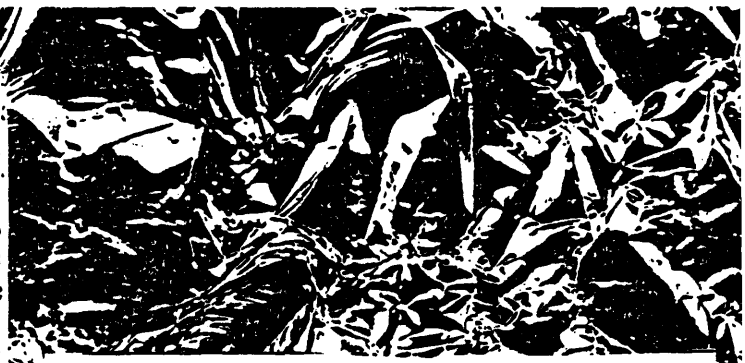
About nine o'clock a large ball of fire paſſed under the zenith, towards the ſouth-eaſt part of the horizon. I have been informed, that a light was obſerved on the weather-cock of Wakefield ſpire, which is about 240 feet high, all the time that the ſtorm continued.

ÆTHERFORCE

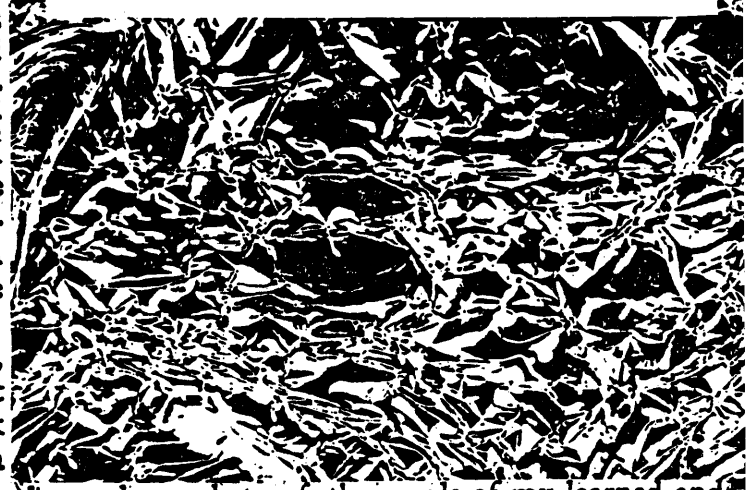
I ſuppoſe the effect would have been greater, but there being a large fire in the room where the experiment was made, on opening the door, in order to introduce the pointed wire, which was twiſted round the inſulated rod, I apprehend, much of the electrified air was diſplaced, by the outer air preſſing in upon it; and driving it to the chimney, &c.

A pair of balls hanging from my hand, near the end of the rod, *in the electrified air*, diverged one inch and an half: but being held near the other end of the rod, *in the unelectrified air*; they diverged only half an inch. I then inſulated the rubber of my machine, and ſtuck a long ſharp-pointed needle in the back of it. Then hanging a chain from my prime-conductor to the table, I began to turn the winch; when the air of the room, the end of the rod, &c. were preſently affected: and the balls at the oppoſite end of it, in the other room, ſoon ſeparated conſiderably more than an inch.

I cannot prevail on myſelf to quit this pleaſing, yet difficult ſubject, without expreſſing a wiſh, that an electrical machine may be conſtructed, to work from ten, to fifty large cylinders, furniſhed with a prime-conductor, batteries, and other apparatus, proportionably large; the whole to be incloſed by brick walls, having flews quite round it, (like an hot-houſe, for botanic purpoſes) to keep the air in the room in a due temperature for experiment. With ſuch a machine as this, properly managed; new, unexpected, and wonderful diſcoveries might be



ATMOSPHERIC INERTIA AND THE WHITE RAY



made: and, to uſe the words of my learned and ingenious friend Dr. PRIESTLEY, they are not philoſophers who think no advantages could be gained by it. Electrical bells ſhould alſo be ſet up, to give notice of electricity, in the atmoſphere; and by a pair of light pith or cork balls, hanging by linen threads from the apparatus, the kind, continuance, and changes of the electricity ſhould be carefully noted. It would alſo be proper to put out occaſionally, a long ſtick, or the ſtrongeſt parts of a fiſhing-rod, having a box, with a pair of light cork balls hanging from thence, at the end of it, which would diſcover much ſmaller degrees of electricity in the air, than is ſufficient to ring bells; and by theſe, the kind of it may be readily aſcertained. Such a courſe of experiments as I have recommended in this paper, would ſoon throw new light upon the ſubject of electricity; hitherto, I believe, but little underſtood; though ſo intereſting to mankind, and ſo highly deſerving the niceſt inveſtigation, of the moſt curious enquirers into nature. But theſe purſuits can be properly attended to, by thoſe only, who are gentlemen of fortune, and leiſure: and could ſuch be prevailed on to undertake them, I have not the leaſt doubt but the exquiſite knowledge of *this ſecret part* of the operations of nature, which they would ſoon attain in the practice, would prove an ample reward of their labours: an honour to their country, and perhaps a benefit to the whole human race.

ÆTHERFORCE

DRAWING DOWN THE WHITE RAY

FRANKLIN'S VINDICATION

Franklin planned to perform the lightning experiment after the completion of the spire on Christ Church, in Philadelphia. In the meantime, his book was published in France and made a deep impression. A scientist named D'Alibard made a secret trial of the sentry box experiment near Paris on May 10, 1752. There was a peal of thunder and the iron shaft sparkled blue with charge pouring into a Leyden jar, proving that the cloud was electrified. Eight days later, the experiment was repeated for the King in Paris.

The King himself wrote to the Royal Society of London, complimenting their member, Franklin. Early in July, his experiment was performed in London. By the time the news reached him in September, he had been world famous for months. Instead of waiting for the completion of the spire, he had meanwhile performed the kite experiment himself, but he ungrudgingly gave D'Alibard credit for having been first to "draw lightning from the skies." However, the world knew that Franklin had suggested the experiment; and the awe with which people looked upon lightning was now added to Franklin's name. He became a figure of magic, a demigod.

The preceding LETTERS *having been translated into* French, *and printed at* Paris; *the* Abbe Mazeas, *in a Letter to Dr.* Stephen Hales, *dated St.* Germain, May 20, 1752. *gives the following Account* (*printed in the* Philosophical Transactions) *of the Experiment made at* Marly, *in pursuance of that proposed by Mr.* Franklin, *Page* 222.

SIR,

The *Philadelphian* experiments, that Mr. *Collinson*, a Member of the Royal Society, was so kind as to communicate to the public, having been universally admired in *France*, the King desired to see them performed. Wherefore the Duke *D'Ayen* offered his Majesty his country-house at St. *Germain*, where M. *de Lor*, master of Experimental Philosophy, should put those of *Philadelphia* in execution. His Majesty saw them with great satisfaction, and greatly applauded Messieurs *Franklin* and *Collinson*. These applauses of his Majesty having excited in Messieurs *de Buffon*, *D'Alibard*, and *de Lor*, a desire of verifying the conjectures of Mr. *Franklin*, upon the analogy of thunder and electricity, they prepared themselves for making the experiment.

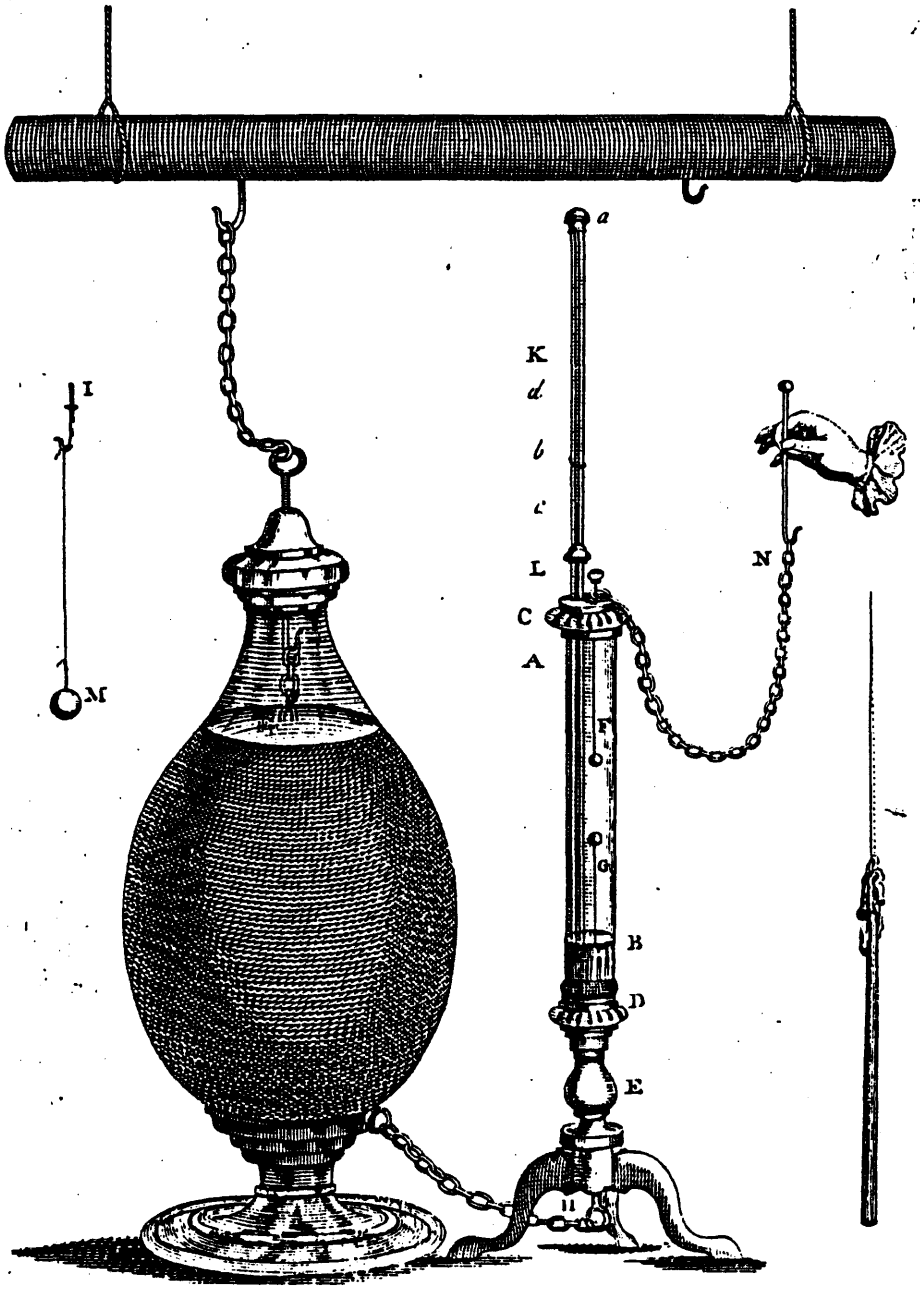
M. *D'Alibard* chose, for this purpose, a garden situated at *Marly*, where he placed upon an electrical body a pointed bar of iron, of 40 feet high. On the tenth of *May*, 20 minutes past two in the afternoon, a stormy cloud having passed over the place where the bar stood, those that were appointed to observe it, drew near, and attracted from it sparks of fire, perceiving the same kind of commotions as in the common electrical Experiments.

M. *de Lor*, sensible of the good success of this experiment, resolved to repeat it at his house in the *Estrapade* at *Paris*. He raised a bar of iron 99 feet high, placed upon a cake of resin, two feet square, and three inches thick. On the 18th of *May*, between four and five in the afternoon, a stormy cloud having passed over the bar, where it remained half an hour, he drew sparks from the bar, like those from the gun barrel, when, in the electrical experiments, the globe is only rubbed by the cushion, and they produced the same noise, the same fire, and the same crackling. They drew the strongest sparks at the distance of nine lines, while the rain, mingled with a little hail, fell from the cloud, without either thunder or lightning; this cloud being, according to all appearance, only the consequence of a storm, which happened elsewhere.

I am, with a profound respect,
Your most humble and obedient servant,

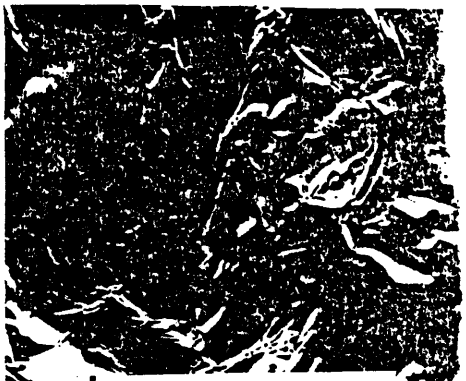
G. MAZEAS.

ÆTHERFORCE



Franklin was first to prove that a spark generated heat. The discharge of a Leyden jar across the gap, F-G, raised the reading on thermometer, *a*.

Lightning rod hats were a 1778 Paris fashion.



In July, 1750, Franklin wrote: "To determine the question whether the clouds that contain lightning are electrified or not, I would propose an experiment. On top of some high tower . . . place a kind of sentry box big enough to contain a man and an electrical stand (*a platform that was insulated*). From the middle of the stand let an iron rod rise and pass bending out of the door, and upright twenty or thirty feet pointed very sharp at the end. If the electrical stand be kept clean and dry, a man standing on it when such clouds are passing low, might be electrified and draw sparks, the rod drawing fire . . . from a cloud . . ."

ATHERFORCE

XVII. *Remarks on the Aurora Borealis.* By Mr. Winn. *In a Letter to Dr. Franklin.*

Spithead, Auguſt 12, 1772.

SIR

Redde, Jan. 20, 1774.

I Have often wiſhed, that ſomebody would carefully collate a ſufficient number of meteorological journals, with intent to obſerve and claſs the ſeveral appearances in the atmoſphere, before great changes in the weather, particularly before great ſtorms. I am perſuaded, from my own obſervation, that, in general, ſufficient indications, of impending tempeſts preceed them a conſiderable time, did we but carefully note them. The phænomenon, which I am going to mention, is one of thoſe indications which not only portend an approaching tempeſt, but aſcertain from what quarter it will come; a circumſtance, that may render it of eſſential ſervice to ſeamen. I believe the obſervation is new, that the *Aurora Borealis* is conſtantly ſucceeded by hard ſoutherly, or ſouth-weſt winds, attended with hazy weather, and ſmall rain. I think, I am warranted from experience, to ſay conſtantly; for in twenty-three inſtances, that have occurred, ſince I firſt made the obſervation, it has invariably obtained. However, I beg leave to requeſt, you will recommend it to the notice of the Royal Society, as a matter, which, when confirmed by further obſervations, and generally known, may be of more conſequence than at firſt appears. To ſhew that it may, give me leave to recite the circumſtance, which firſt occaſioned my taking notice of it. Sailing down the Engliſh channel in 1769, a few days before the autumnal equinox, we had a remarkably bright and vivid *Aurora* the whole night. In ſhore, the wind was fluctuating, between N.N.W. and N.W. and farther out, W.N.W. Deſirous of benefiting by the land wind, and alſo of taking advantage of an earlier ebb-tide, I diſpenſed with the good old marine adage, *never to approach too near a weather-ſhore, leſt it ſhould prove a lee-ſhore*, and, by ſhort tacks, clung cloſe along the Engliſh coaſt. Next day, the wind veered to the S.W. and ſoon after to S.S.W. and ſometimes S. We were then in that dangerous bay between Portland and the Start Point, and carried a preſſing ſail, with hopes of reaching Torbay before dark; but night fell upon us, with thick haze, and ſmall rain, in ſo much, that we could not have ſeen the land at the diſtance of a ſhip's length. The gale was now increaſed to a ſtorm; in this dilemma, nothing remained but to endeavour to keep off the ſhore, till the wind ſhould change. Luckily our ſhip was a ſtout one, and well rigged.

Reflecting ſome time after, on the circumſtances of this ſtorm, and the phænomena that preceded it, I determined to have particular attention to

 future

future *Auroræ*, and the weather, that ſhould ſucceed them; and, as I have obſerved above, in twenty-three inſtances, have found them uniform, except in degree: the gale generally commencing between twenty-four and thirty hours after the firſt appearance of the *Aurora*. More time and obſervation will probably diſcover, whether the ſtrength, of the ſucceeding gale, is proportionate to the ſplendor and vivacity of the *Aurora*, and the diſtance of time between them. I only ſuſpect, that the more brilliant and active the firſt is, the ſooner will the later occur, be more violent, but of ſhorter duration, than when the light is languid and dull. Perhaps too, the colour of the *Aurora* may be ſome guide, in forming a judgement of the coming gale. That which preceeded the ſtorm I have mentioned, was exceedingly ſplendid. The tempeſt ſucceeded it in leſs than twenty-four hours, was violent, but of ſhort (about eight hours) continuance. In June laſt, a little without ſoundings, we had for two nights following, faint inactive *Auroræ*; the conſequent gale was not hard, but laſted near three days: the firſt day attended with haze, and ſmall rain; the ſecond with haze only, and the laſt day clear.

The benefit which this obſervation, on the *Aurora Borealis*, when further confirmed and known, may be of to ſeamen, is obvious, in navigating near coaſts, which tend eaſt and weſt, particularly in the Britiſh channel. They may, when warned by the *Aurora Borealis*, get into port, and evade the impending ſtorm; or, by ſtretching over to the ſouthward, facilitate their paſſage, by that very ſtorm, which might have deſtroyed them; for no winds are ſo dangerous, in the channel, as ſoutherly and ſouth-weſt. In a word, ſince I have made this obſervation, I have got out of the channel, when other men, as alert, and in faſter ſailing ſhips, but unapprized of this circumſtance, have not only been driven back, but with difficulty have eſcaped ſhipwreck.

Perhaps, the obſervation, that ſoutherly gales conſtantly ſucceed theſe phænomena, may help to account for the nature of the *Aurora Borealis*; my own thoughts on that ſubject, I ſhall ſome time beg leave to lay before you.

I am, with great reſpect,

SIR,

Your obliged,

humble ſervant,

J. S. WINN.

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MERGING THE BLACK AND WHITE RAYS

Mr. Hauksbee, whose writings are dated 1709, distinguished himself by experiments and discoveries in electrical attraction, and repulsion, and electric light. He constructed an electrical machine, adopting the glass, instead of the sulphur globe. He experimented upon the subtilty and copiousness of the electric light, and likewise upon the sound and shocks produced by the fluid. After the death of Mr. Hauksbee, the science of electricity made but slow progress, and few experiments were made for twenty years. In the year 1728, Mr. Stephen Grey, a pensioner at the Charter House, commenced his experiments with an excited glass tube. He and his friend, Mr. Wheeler, made a great variety of experiments in which they demonstrated, that electricity may be communicated from one body to another, even without being in contact, and in this way, may be conducted to a great distance. Mr. Grey afterwards found, that, by suspending rods of iron by silk or hair lines, and bringing an excited tube under them, sparks might be drawn, and a light perceived at the extremities in the dark. He electrified a boy suspended by hair lines; and communicated electricity to a soap bubble blown from a tobacco pipe. He electrified water, contained in a dish, placed upon a cake of rosin, and also a tube of water. He made some curious experiments upon a small cup of water, over which, at the distance of an inch, he held the excited tube. He observed the water to rise in a conical shape, from which proceeded a light; small particles of water were thrown off from the cone, and the tube moistened.

Mr. Du Fay, intendant of the French king's gardens, repeated the experiments of Mr. Grey in 1733. He found that by waxing the pack-thread he succeeded better with the experiment of communicating the electric virtue through a line 1256 feet in length. He made the discovery of two kinds of electricity, which he called *vitreous* and *resinous;* the former produced by rubbing glass, and the latter from excited sulphur, sealing wax, &c. But this he afterwards gave up as erroneous. Mr. Grey, in 1734, experimented upon iron rods and gave rise to the term *metallic conductors.* He gave the name *pencil* of *electric light* to the stream of electricity, such as is seen to issue from an electric point. He suggested the idea that the electric virtue of the excited tube was similar to that of thunder and lightning, and that it could be accumulated.

Dr. Desaguliers commenced his experiments in 1739. He introduced the term *conductor* to that body to which the excited tube conveys its elec-

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tricity. He called bodies in which electricity may be excited by rubbing or heating, *electric per se;* and *non-electric* when they receive electricity, and lose it at once upon the approach of another non-electric. In the year 1742, several Germans engaged in this subject. Mr. Boze, a professor at Wittemburg, revives the use of Hauksbee's globe, instead of using Grey's glass tube, and added to it a *prime conductor*. Mr. Winckler substituted a cushion instead of the hand, which had before been employed to excite the globe. Mr. P. Gordon, a Benedictine monk and professor of philosophy at Erford, was the first who used a *cylinder* instead of a globe. With his electrical machine he conveyed the fluid through wires 200 ells in length and killed small birds. Dr. Ludolf of Berlin, in the year 1744, kindled by electricity the *ethereal spirit* of Frobenius, by the excited glass tube; the spark proceeding from an iron conductor. Mr. Boze fired gunpowder by electricity. Mr. Gordon contrived the electrical star. Mr. Winckler contrived a wheel to move by the agency of the same fluid. Mr. Boze conveyed electricity from one man to another by a jet of water, when both were placed upon cakes of rosin, six paces apart. Mr. Gordon fired spirits, by a jet of water; and the Germans invented the electrical bells.

Mr. Collinson in 1745 sent to the Library Company of Philadelphia, an account of these experiments, together with a tube, and directions how to use it. Franklin, with some of his friends, immediately engaged in a course of experiments, the results of which are well known. He was enabled to make a number of important discoveries, and to propose theories to account for various phenomena, which have been universally adopted, and which bid fair to endure for ages.

In the year 1745, such was the attention given to the subject of electricity, that experiments upon it were publicly advertised and exhibited for money in Germany and Holland. Dr. Miles, of England, in the same year fired phosphorus by the application of the excited tube itself without the intervention of a conductor. It was at this period that Dr. Watson's attention was given to this subject. He fired air, made inflammable by a chemical process, and discharged a musket by the electric fluid. He made many experiments, some of which will be described as we proceed.

The year 1745 was made famous by the discovery of the *Leyden Phial* by Mr. Cuneus a native of Leyden. It appears also to have been discovered by Mr. Von Kleist, dean of the Cathedral in Camin about the same time. By this discovery, electricity could be accumulated and severe shocks given. Mr. Gralath, in 1746, gave a shock to twenty persons at once, and at a considerable distance from the machine. He constructed the electrical battery by charging several phials at once. Mr. Winckler, and also M. Monnier, in France, transmitted the electric fluid through several feet of water as a part

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of the circuit. M. Nollet, in France, killed birds and fishes by the discharge of the Leyden jars. Improvements were made by Dr. Watson, and others, in the Leyden phial, by coating the inside and outside of it with tin foil. Abbe Nollet gave a shock to 180 of the guards in the king's presence; and at the grand convent of the Carthusians in Paris, the whole community formed a line of 3600 feet in length, by means of wires between them. The whole company upon the discharge of the phial, gave a sudden spring at the same instant. The French philosophers tried the same experiment through a circuit of persons, holding wires between them, two and a half miles in length. In another experiment the water of the basin in the Tuilleries was made a part of the circuit.

M. Monnier, the younger, to discover the velocity of electricity, discharged the Leyden phial through an iron wire 4000 feet in length, and another 1319 feet, but could not discover the time required for its passage. Dr. Franklin communicated his observations, in a series of letters, to his friend Collinson, the first of which is dated March 28, 1747. In these he shows the power of points in drawing and throwing off the electrical matter. He also made the grand discovery of a *plus* and *minus*, or of a *positive* and *negative* state of electricity. Shortly after Franklin, from his principles of plus and minus state, explained, in a satisfactory manner, the phenomena of the Leyden phial. Dr. Watson and others in July 18, 1747, conveyed the electric fluid across the Thames at Westminster bridge; the width of the river making a part of the circuit. On the 24th of July, he tried the experiment of forcing the electric fluid to make a circuit with the bend of the river, at the New River at Stoke, Newington. He supposed that the electric fluid would follow the river alone, through its circuitous windings, and return by the wire. He suspected from the result of this experiment, that the ground also conducted the fluid. On the 28th, he proved the fact by supporting a wire 150 feet in length upon baked sticks, using the ground as half of the circuit. On the 5th, of August, he tried another experiment of making the *dry* ground a part of the circuit for a mile in extent, and found it to conduct equally as well as water. The last experiment was tried at Shooter's Hill, on the 14th of August of the same year. But one shower of rain had fallen for the five preceding weeks. The wires, two miles in length, were supported upon baked sticks, and the dry ground was used for the return two miles of the circuit. They found the transmission of the electric fluid to be instantaneous. Dr. Watson made many other experiments which we must pass over.

Mr. Ellicott constructed an electrometer for measuring the quantity of electricity. Mr. Maimbury, at Edinburg, electrified two myrtle trees, during the month of October, 1746, when they put forth small branches and

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blossoms sooner than other shrubs of the same kind, which had not been electrified. The same experiment was tried upon seeds, sowed in garden pots with the same success. Mr. Jallabert, Mr. Boze and the Abbé Menon principal of the College of Bueil, at Angers, tried the same experiments upon plants, by electrifying bottles in which they were growing. He proved that electrified plants always grew faster, and had finer stems, leaves and flowers than those which were not electrified.

In the year 1748, Dr. Franklin, and his friends, held an *electrical feast** on the banks of the Schuylkill near Philadelphia, and as the account is amusing, as well as scientific, we will give an account of it as related by Franklin, in a letter to his friend Collinson, dated Philadelphia, 1748. (1 vol. of Franklin's Works, p. 202.)

"Chagrined a little that we have been hitherto able to produce nothing in this way of use to mankind; and the hot weather coming on, when electrical experiments are not so agreeable, it is proposed to put an end to them for this season, somewhat humorously, in a party of pleasure, on the banks of the *Skuykil.*"

"Spirits, at the same time, are to be fired by a spark sent from side to side through the river, without any other conductor than the water, an experiment which we some time since performed, to the amazement of many. A turkey is to be killed for our dinner by the *electrical shock*, and roasted by the *electrical jack*, before a fire kindled by the *electrified bottle:* when the healths of all the famous electricians of England, Holland, France, and Germany are to be drank in *electrified bumpers*,† under a discharge of guns from the *electrical battery.*"

"In the year 1749, Franklin first suggested his idea of explaining the phenomena of thunder gusts, and of the aurora borealis, upon electrical principles. He points out many particulars in which lightning and electricity agree; in the same year he conceived the bold idea of ascertaining the

* "As the possibility of this experiment has not been easily conceived, I shall here describe it. Two iron rods, about three feet long, were planted just within the margin of the river, on the opposite sides. A thick piece of wire, with a small round knob at its end, was fixed on the top of one of the rods, bending downwards, so as to deliver commodiously the spark upon the surface of the spirit. A small wire, fastened by one end to the handle of the spoon containing the spirit, was carried across the river, and supported in the air by the rope commonly used to hold by, in drawing ferry boats over. The other end of this wire was tied round the coating of the bottle; which being charged, the spark was delivered from the hook to the top of the rod standing in the water on that side. At the same instant the rod on the other side delivered a spark into the spoon and fired the spirit; the electric fire returning to the coating of the bottle, through the handle of the spoon and the supported wire connected with them."

† "An electrified bumper is a small thin glass tumbler, nearly filled with wine, and electrified as the bottle. This, when brought to the lips, gives a shock, if the party be close shaved, and does not breathe on the liquor."

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truth of his doctrine, by actually drawing down the lightning, by means of sharp pointed iron rods, raised into the region of the clouds. Admitting the identity of electricity and lightning, and knowing the power of points in repelling bodies charged with electricity, and in conducting the fluid silently and imperceptibly, he suggested the idea of securing houses, ships, &c. from being damaged by lightning, by raising pointed rods several feet above the most elevated part of the building to be protected, and the other end descending some feet into the ground. It was not until the summer of 1752, that he was enabled to complete his grand discovery by experiments."

"While he was waiting for the erection of a spire, it occurred to him that he might have more ready access to the region of clouds, by means of a common kite. He prepared one by fastening two cross sticks to a silk handkerchief, which would not suffer so much from the rain as paper. To the upright stick was affixed an iron point. The string was, as usual, of hemp, except the lower end, which was silk. Where the hempen string terminated, a key was fastened. With this apparatus, on the appearance of a thunder gust approaching, he went out into the commons, accompanied by his son, to whom alone he communicated his intentions, well knowing the ridicule which, too generally for the interests of science, awaits unsuccessful experiments in philosophy. He placed himself under a shade, to avoid the rain; his kite was raised—a thunder cloud passed over it—no sign of electricity appeared. He almost despaired of success, when, suddenly, he observed the loose fibres of his string to move towards an erect position. He now presented his knuckle to the key, and received a strong spark; repeated sparks were drawn from the key; a phial was charged, a shock given, and all the experiments made which are usually performed with electricity."

"Franklin constructed rods so as to bring the lightning into his house, for the purpose of ascertaining if it was of the positive or negative kind. He succeeded in the experiment for the first time in April, 1753, when it appeared that the electricity was negative. On the 6th of June he met with a cloud electrified positively. The discoveries of Franklin roused the attention of all Europe, and many distinguished electricians repeated them with success. Professor Richman, of St. Petersburg, while making some experiments upon the electrical state of the atmosphere, was killed by the electric fluid, August, 1753. Towards the end of the eighteenth century, electricity was assiduously cultivated by a great number of eminent individuals, who extended the boundaries of the science by numerous experiments, and by the invention of ingenious and useful instruments. Experiments were made upon air, water and ice; and in relation to the surfaces of electric bodies; in relation to the two electrical states; upon the deflagration of the metals; decomposition of solids and liquids," &c. &c.

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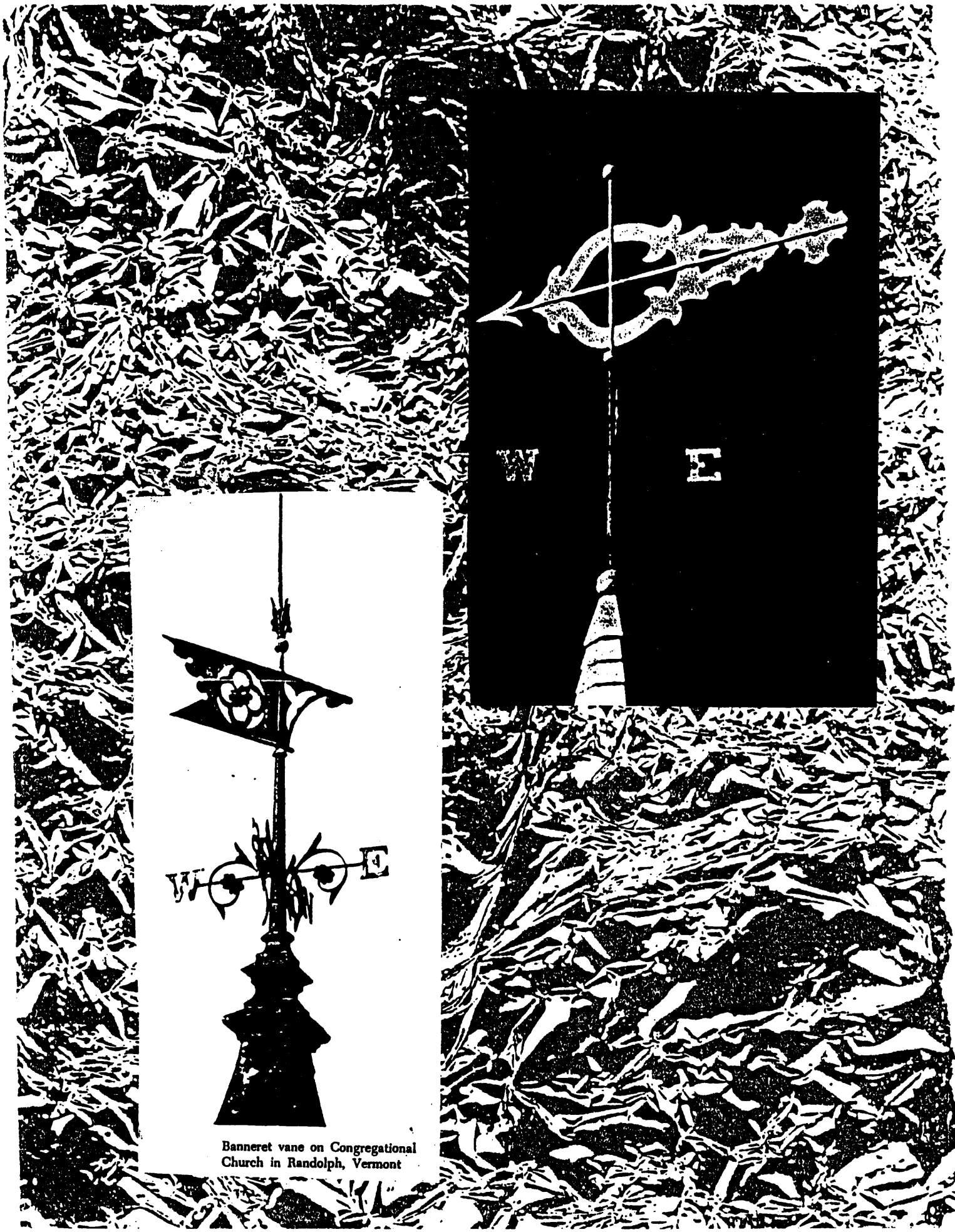

Banneret vane on Congregational Church in Randolph, Vermont

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Professor Henry of the Smithsonian Institute on Lightning Rods.

In answer to a letter of inquiry as to the best method of erecting and constructing lightning rods, Professor Henry gives the following instructions:

1. The rod should consist of round iron of about one inch in diameter; its parts, throughout the *whole* length, should be in perfect metallic continuity, by being secured together by coupling ferrules.

2. To secure it from rust the rod should be coated with black paint, itself a good conductor.

3. It should terminate in a single platinum point.

4. The shorter and more direct the course of the rod to the earth the better; bendings should be rounded, and not formed in acute angles.

5. It should be fastened to the building by iron eyes, and may be insulated from these by cylinders of glass (I don't, however, consider the latter of much importance).

6. The rod should be connected with the earth in the most perfect manner possible, and nothing is better for this purpose than to place it in metallic contact with the gas-pipes, or, better, the water-pipes of the city. This connection may be made by a ribbon of copper or iron soldered to the end of the rod at one of its extremities, and wrapped around the pipe at the other. If a connection of this kind is impracticable, the rod should be continued horizontally to the nearest well, and then turned vertically downward until the end enters the water as deep as its lowest level. The horizontal part of the rod may be buried in a stratum of pounded charcoal and ashes. The rod should be placed, in preference, on the west side of the building. A rod of this kind may be put up by an ordinary blacksmith. The rod in question is in accordance with our latest knowledge of all the facts of electricity. Attempted improvements on it are worthless, and, as a general thing, are proposed by those who are but slightly acquainted with the subject.

Sept. 25, 1866.

Insulation of Lightning Rods.

MESSRS. EDITORS:—A correspondent in your number for Sept. 8th says, "It is a common *error* to suppose that lightning rods should be insulated." Had he said common *belief*, he would have been nearer right: but whether error or belief, it is an argument against him, under the old maxim that what "everybody believes must be true." In fact, the belief, or error, if you choose, is almost universal. Almost all men who have made electricity a study believe and teach it, and the rest of the world believe it because so taught. All our electric telegraph men believe and practice it. But, says your correspondent, "the lightning rod ought rather to be so contrived as to facilitate free passage from the building to the rod and thence to the atmosphere, and *vice-versa*." If *so*, let us have our lightning rods laid with our courses of brick or clapboards, and sticking through our roofs with one end in the building and the other out; for, in that position, they could certainly much better facilitate the free passage from the building to the atmosphere, and *vice-versa*.

It is true that "currents of electricity are continually circulating through masses of matter in a rarefied state," and by so doing perform a very useful office, and we need no lightning rods to rid us of the friend, but when it comes in bolts, on the outside of our dwellings, then we prefer to interpose some "obstruction" to its passage into the dwelling.

I cannot conceive of any appositeness in comparing a lightning rod to a safety valve. We certainly do not generate electricity in our dwellings in dangerous quantities, as a boiler does steam, and if we did I should want the safety valve on conductors leading it out as above suggested, and not stapled on the outside merely. It would seem that a lightning rod should be rather a shield than a valve, and to not insulate it is to leave it so that the bolts may penetrate it and do damage beyond it. It is true, as he tells us, that the rod should be brought in "metallic contact" with all important metallic substances on the outside of the building. But why? Simply because the rod will be relieved thereby of so much electricity as will be required to charge such metal, just as lateral points relieve the rod by discharging any overload from it; but if his theory is correct, why not connect the rod with any metals within the house as well as outside?

Prof. Horace Mann, late of Antioch College, than whom there is no higher authority on this subject, says, "The old method of fastening the rod to the house by an iron staple, is a direct invitation, or rather a direct command, to the lightning to come in; and when it does come in, we all know what liberties it takes. Electricity, indeed, is valuable, is indispensable in all our dwellings, but not in the form of bolts."

But, Mr. Editor, while I thus argue for insulation, I would not mislead, and, therefore, say I do not mean glass rings. I do not consider any rod as insulated which runs through glass, for, when the electricity destroys the glass, as it is sure to do if in the form of bolts, then the rod immediately falls in contact with the staple which held the glass, and becomes, in fact, a stapled rod, and the records are full of disasters caused by such rods: indeed, people seeing their failures, and believing them to be, as they are generally called, lightning rods, have come to be skeptical of the value of all rods.

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Effect of Lightning.

Dr. Boudin, says the *Mechanics' Magazine*, has sent a note to the Academy of Sciences on the fulminating power of bodies recently struck by lightning, and of which he adduces two remarkable instances. On the 30th of June 1854, a man was killed by lightning near the Garden of Plants at Paris; the body remained for some time exposed to a pouring rain. After the storm two soldiers, in attempting to lift up the body, received two violent shocks. In the other case, which occurred at Zara, Dalmatia, two artillerymen who had been ordered to set up again in their former places two telegraphic posts that had been thrown down during a storm; took hold of the telegraphic wire. Although it was two hours after the storm, there was so much electricity left that the men first experienced a few slight shocks, and then were both thrown to the ground. The hands of both were scorched, and one of them did not even for a time show any signs of life. The other, in attempting to get up, sank down again, and in so doing touched a comrade, who was coming to his assistance, with his elbow. The third man was then thrown down in his turn, experienced various nervous effects, and his arm was marked with a burn at the spot where he had been touched by the other man's elbow.

Interesting Electrical Experiment.

Astonishing as is the fact of the concentration of the power of a lightning flash into a minute interval, yet as wonderful is the extent of the earth's surface affected by it, as will be seen from the following experiments of the writer, never before published: A galvanometer consists of a delicately suspended magnetic needle surrounded by a coil of copper wire, through which a current of electricity can pass; whenever this passage takes place the needle rapidly turns around its point of suspension. This being understood, I connected the wire of a galvanometer with the water pipes of Baltimore, and the other end of the coil was joined to a gas pipe of a house in the southwest part of the city. Thus a vast metallic system of electric nerves stretched away three miles to the northwest, to the reservoir, and about as many to the east and southeast over the city. A thunder storm was raging at the time, at so great a distance in the north that only the illumination of the clouds told when a flash occurred. Yet, whenever that flash took place, the needle was instantly deflected through ten or twenty degrees. The two occurrences were simultaneous, apparently, for I could detect no difference in the instant of their manifestation.

Electrical Phenomena.

Messrs. Editors:—Some weeks since, during a severe blow the subtle fluid played some fantastic tricks. The weather was fair, scarcely a cloud visible near us, and the wind blew a small gale by way of amusement. The current came from the southwest, and traveled a little north of east. Over the mountains whence the wind came, there were heavy snow-clouds part of the time, say 20 to 25 miles distant.

During the blow, which lasted two days with intervals of intermission, stoves with pipes projecting from roofs, became highly charged with electricity, which on the near approach of persons were rapidly discharged with sparks, shocks, and pricking sensations to the parties approaching. One lady experienced the sensations in her finger nails, another in the tips of the fingers, and one finding a convenient battery, and being in poor health, kept the current passing through her body as long as possible. The charge was strongest during the highest wind; neither stoves or person was insulated. Some of the stoves were cast-iron, others sheet-iron. All I have examined were standing on the floors of pine boards. In one instance the sparks were shaken from all the fingers at once. The facts are well attested by witnesses numerous and reliable.—Jon. H. Wolff.

Denver City, Jan. 10, 1862.

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You quote from Lyon in his ninth requisite, "the rod should run along the whole length of the ridge," which, if the ridge is level, will have many places between the insulators where the lightning will have to run up hill. No serious effect would come from this, providing the rod was large enough to carry the charge, but if not, it will jump off and seek some other road to the ground. Numerous instances of this kind have come under my observation. The most frequent are those on the telegraph line. In all offices between the main offices of the line, the wire is brought in at the top of the ceiling, and, running along near the instrument, descends several feet where the cut-off is—which is used to detach the instrument during a thunder storm—and then returns. Usually the wire in the office is copper and smaller than the iron wire outside.

Now the effect of a heavy stroke on the line is usually this: If it strikes a pole first, the top above and below the insulator, is broken, part of the charge goes down the pole, the rest goes on the wire, and if it does not melt the wire between the poles and jump off, it will break the next pole below the insulator, showing that the wire could not carry all the charge when there was anything to jump to. Sometimes half a dozen poles will show the effect of this single stroke, and still the wire will have all it can carry. The first office this goes into it will jump from the copper wire to the ground wire, sometimes a couple of feet. Operators have learned this secret and usually have the ground wire close to the cut-off.

Your correspondent from Ohio, in No. 11, is right in speaking about insulation, as I believe it does no good but rather injury; but I differ with him in connecting the rod to the gutters, spouts, etc. Lightning don't seem to care how far it goes in getting to the earth providing it has a good road to travel. Last summer our school house was struck. The rod was in contact with the gutter, part of it went on the conductor to the cistern and burst it.

To secure a house against descending and ascending strokes, I would run strips of copper up each corner of the building, under the siding, over the roof boards and under the shingles, and terminate them with a point at the ends of the ridge. These, in good connection with the ground, will secure the house against all ascending strokes; still I would have a good rod, the best and cheapest of which is a small iron cable, half or three-quarters of an inch in diameter, with a steel point, all painted black and spiked to the building with staples, and descending all the way from the point to the ground.

It would be a good plan to have the tin conductor connected with the ground with a copper strip to save the cistern.

W. E. P.

Lacon, Ill., Sept. 10, 1866.

Lightning-Rod Insulation.

MESSRS. EDITORS:—I am glad to see you are ventilating the subject of lightning rods, for it greatly needs it, to save the community from swindlers, and to protect its lives and property. In your last article you say "some advocate insulation, and some argue against it," although it is plain from your former article that you agree with most scientific men, that it is desirable. But the question arises, what is insulation? In your first article you say, "passing the rod *through* glass insulators does not seem to be always effective," and yet nine-tenths of the rods peddled through the country are put up with such glass rings, and are called insulated rods. Hence the prejudice against insulation, and with many against all rods. They see the failures, and not knowing the cause, condemn indiscriminately. As well might they condemn all medical treatment of disease for the same reason. A properly insulated lightning rod should never pass through the glass, nor come in contact with it, for when a bolt of electricity, following a rod, comes in contact with a body of glass, it is very sure to shatter it, leaving the rod in contact with the staple or strap which held the glass to the building, in which case the rod is no better or worse than a rod put up without insulation, and fastened with staples directly to the building, which rod *may* conduct the bolt safely off, but is dangerous if overloaded, or improperly entered in the ground, or if its connections are the least impaired. A few years since, the house of Mr. Conrad Swackhamer, at Fort Washington, was furnished with lightning rods which were supported by being wired to the outer end of glass knobs. The rod was struck and the glasses were shattered all over the house, but as there were no surrounding staples or straps for the bolt to follow into the building, it passed safely to the ground. Mr. S. having learned wisdom by experience, procured insulators to repair his rod which do not permit the rod to impinge upon the glass. By this example we see the necessity of not only insulating the rods, but of preventing all contact of rod with the glass used for insulation, and we see also the reason for the frequent failures of glass-ring insulators.

J. D. WEST.

Philadelphia, Aug. 16, 1866.

P. S. After finishing this paper, I found an account of an aerial voyage among the clouds during a thunder storm, made in Ohio, in 1832, by Mr. Wise, in which he had occasion to observe the formation, by electricity, of an uprising whirlwind or tornado, and also of hail stones. A hail storm is acknowledged, long ago, to be an electric phenomenon, and lightning rods have been suggested to be raised on a kind of telegraph poles, at regular distances, in districts subjected to destructive hail storms. They are said to be partially, and in some localities, perfectly successful.

P. H. V. W.

ÆTHERFORCE

THOUGHTS ON COSMICAL ELECTRICITY.[1]

BY PROF. ELIHU THOMSON.

PROF. THOMSON prefaced his remarks by stating that it was not his intention to give an illustrated popular lecture, but rather to present to the Electrical Section of the Institute a number of thoughts which had come to him, and which must be regarded as in the nature of speculations or guesses. He had attempted to apply known principles to conditions of the heavenly bodies, and he thought there was much to learn in this field.

Beginning with the consideration that as we rise from the earth's surface to different altidudes there appears to be a gradual increase of potential with respect to the ground, such that at a thousand feet, as at the top of the Eiffel tower, there may be 10,000 volts difference between the air at the top and the surface, he assumed that this difference might increase as we reach high altitudes, and that at 20 or 30 miles the potential difference might amount to a million volts more or less. This would seem to indicate the possession of a positive charge by the higher layers of the atmosphere. He stated, however, that it had not yet been proved that a pure gas could carry a charge of electricity, and instanced the case of a drop of water suspended in the air and charged to a certain potential; if the air were dry and the drop evaporated, the potential would rise gradually until, when it was entirely evaporated, the potential would be infinite. This consideration would be based on the fact, if it be a fact, that liquids in evaporating do not part with their electricity. The increased potential of the drop, however, might have other effects, such as the repulsion of its particles and its division into an extremely comminuted state. Still, on evaporation to pure vapor the electricity must go somewhere.

1. Abstract of a lecture delivered before the Electrical Section of the Franklin Institute, Tuesday, December 12, 1893.

After stating the nature of the electrical charge as dependent upon capacity and potential, he showed that whenever the capacity is diminished, the potential with a given amount of electricity rises, and vice versa; but went on to state that attraction and repulsion, and other phenomena could be explained by the general tendency of all bodies to increased capacity. He adduced considerations going to show that there was a relative repulsion between liquid charges of electricity besides the attraction between opposite charges, and that therefore, the lines of electrostatic stress would agree with those of magnetism in their tendency to shorten and also to spread laterally.

He then took up the question as to whether a perfect vacuum is, or is not, a conductor of electricity and brought forward the results of recent investigations as showing that an excellent vacuum is not a conductor, but on the other hand is the most perfect insulator. Taking this in connection with the fact that dense air is a good insulator, that rarefied gas is a fair conductr, and that the solid body of the earth is a conductor, he compared the earth to a huge condenser possessing a positive charge in the outer layers, while the earth itself might be less positive or negative. Using the results of Prof. Rowland's works on the movement of a charged body giving rise to magnetism, and the principle of an air condenser, he put forward the idea that the earth, being a huge rotating condenser with a positive charge in the upper layers of the atmosphere and negative charge at the ground, it would necessarily follow that the magnetism could be developed in the region between this upper layer and the earth by the rotation of these charges.

He then traced the actual direction of the magnetism which would be produced, finding that the direction was the proper one to accord with facts and that the compass needle indicates the direction. He reverted to the idea which had come to him that possibly thunder storms were in a measure due to flaws in the dense air as a dielectric and explained in detail, somewhat, his thoughts on this subject. He drew attention to the consequences which would follow the possession by a mass of nebulous gas of a charge of electricity; this, if insulated in space, would, as its volumes diminished by the radiation of heat and condensation, gradually increase in potential, however small the charge originally possessed. The sun might, therefore, be a charged body having a relatively high potential, which potential would undergo elevation on further condensation. He put forward, as a thought on this subject, a possible explanation of the solar periods as due to electrical states, the sun reaching a certain potential and then by the repulsion of small electrified particles losing that potential by the passing of the coronal stream, and not only a part of the charge which it possessed, but also a considerable amount of the charged material which might be encountered by the earth in its movement around the sun, and so gave rise to an auroral display. He showed that the action would necessarily be the periodic one. He showed the tendency of electrified bodies to lose their charge, especially in the presence of rays of light and the higher rays of the spectrum, and thought that this action might possibly have some relation to the possession of and disposition of charges by the heavenly bodies.

He concluded the lecture by stating that it was possible, in his opinion, that temporary stars, that is, stars becoming visible and then fading away, might therefore be explained on an electrical hypothesis, viz., that charged bodies possessing a difference of electrical potential when they approach near enough might exchange electricity between themselves on the grandest scale, giving rise to a uniformity of charge on their leaving each other; that this would naturally be done in a vast display which would only last for a moment of time. He stated in conclusion that these were only thoughts after all, but such as he believed would be of interest to the members of the Section.

ÆTHERFORCE

J. S. BARBER.

Lightning Rod.

No. 1.096. Patented March 5, 1839.

Fig. 1.

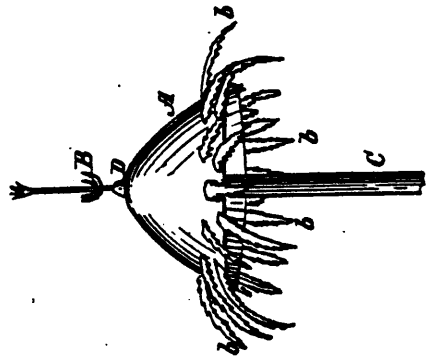
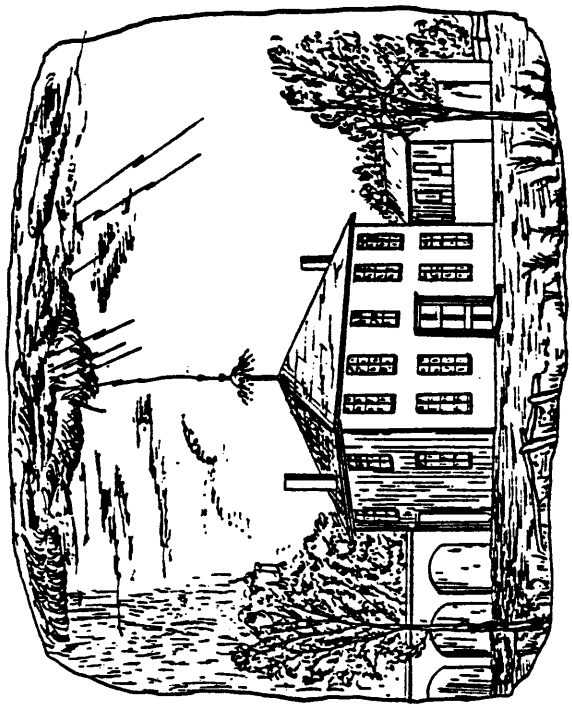


Fig. 2.



ÆTHERFORCE

UNITED STATES PATENT OFFICE.

JOS. S. BARBER, OF GLOUCESTER, MASSACHUSETTS.

IMPROVEMENT IN THE LIGHTNING-RODS FOR PROTECTING BUILDINGS, &c., FROM THE EFFECTS OF LIGHTNING.

Specification forming part of Letters Patent No. **1,096**, dated March 5, 1839.

To all whom it may concern:

Be it known that I, JOSEPH S. BARBER, of Gloucester, Essex county, State of Massachusetts, have invented new and useful improvements on the modes generally practiced of protecting buildings or other property from the destructive effects of lightning, of which the following is a specification.

My improvements, the principles thereof, the manner in which I have contemplated the application of those principles by which the same may be distinguished from other inventions, together with those parts, improvements, or combinations I claim as my inventions and discoveries, I have hereinafter set forth and described, which description, taken in connection with the accompanying drawings herein referred to, forms my specification.

Figure 1 represents a view of my invention. Fig. 2 will serve to show its application to a building and its mode of operation.

A is a hollow paraboloid or other suitable shaped body, constructed of copper or any good conducting metal, having attached to its lower side any desirable number of leaved, notched, or pointed pieces of metal, *b b b b*, shaped and arranged as seen in the drawings, or otherwise properly formed to answer their intended purposes.

To the top of the body A a set of branching wire points (of any conducting metal) is fixed, as seen at B, Fig. 1, constructed as there represented, or in any other suitable manner.

The whole of the above apparatus is to be mounted on a long staff of wood, C, or other proper non-conductor of the electric fluid, which staff is to be applied to some suitable part of the top of a house or other building, as represented in Fig. 2. Between the top of the staff C and the shoulder D (through which the rod passes) there may be interposed a quantity of resin, through which the rod B also passes into the staff, the resin being a more perfect non-conductor, and thereby more effectually protecting the building to which the apparatus is attached. The electricity being attracted from a cloud by the points B will be dispersed or disseminated through the atmosphere by the points of the metallic leaves *b b b b*, the staff or non-conductor C preventing the fluid from injuring the building.

Should one of the above apparatus not be deemed sufficient to protect any house on which the same may be erected, two or more may be used, which, in order to diffuse the lightning more effectually should it strike either, may be connected by a wire or wires extending from the metallic body of one to that of the other.

Having thus described my improvements, I shall claim as my invention as follows, viz:

A paraboloid, constructed as above described, and its combination with a set of branching wire points in the manner above described, and for the purpose above set forth.

In testimony that the above is a true description of my said invention and improvements I have hereto set my hand this 14th day of July, in the year 1838.

JOS. S. BARBER. [L. S.]

Witnesses:

R. H. EDDY,

EZRA LINCOLN, Jr.

ÆTHERFORCE

R. L'ANGLAIS.

Lightning-Rod Insulator.

No. 4,807. Patented Oct. 7, 1846.

Fig. 1.

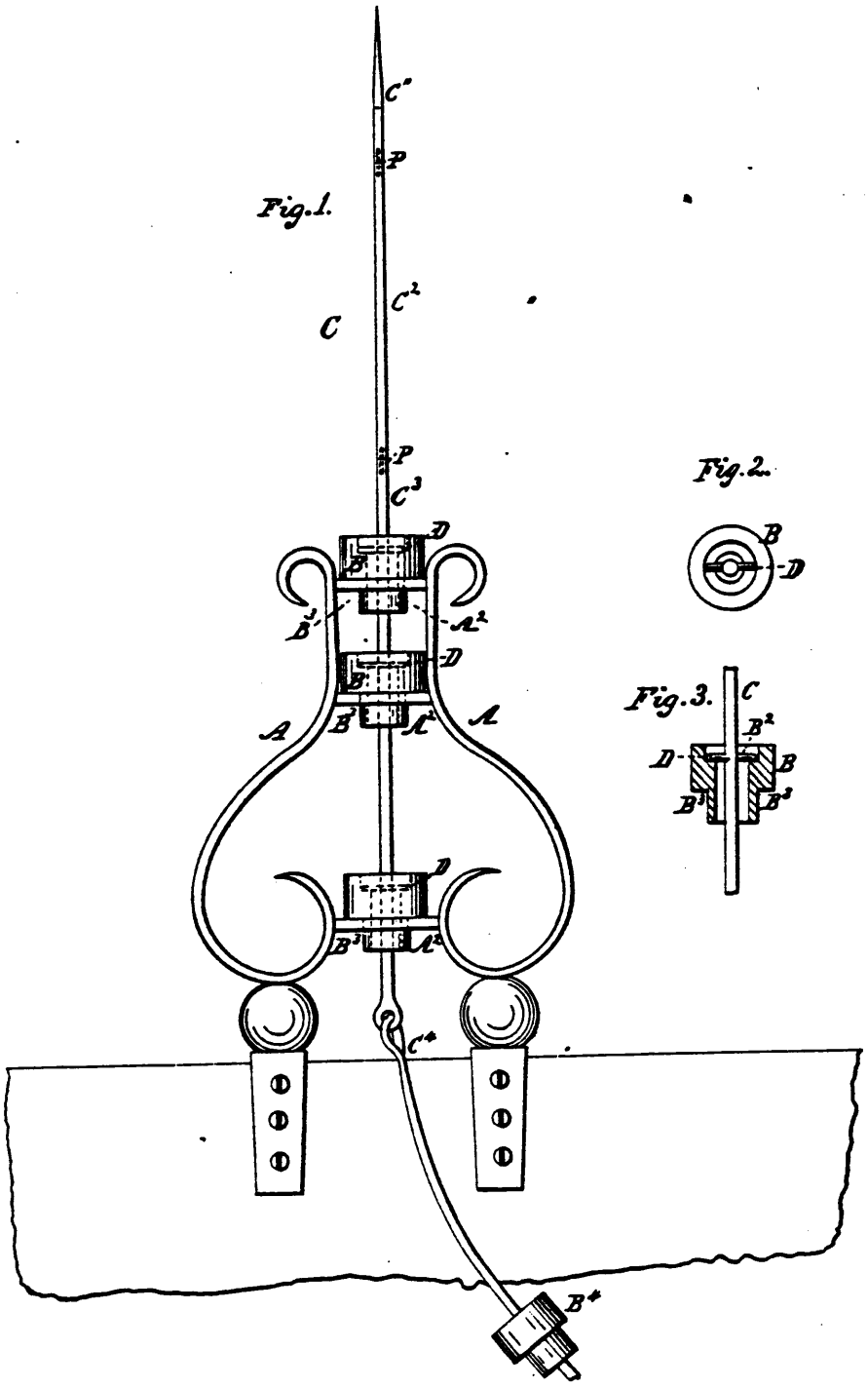


Fig. 2.

Fig. 3.

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UNITED STATES PATENT OFFICE.

RÉNÉ L'ANGLAIS, OF ASSUMPTION COUNTY, LOUISIANA.

IMPROVEMENT IN LIGHTNING-CONDUCTORS.

Specification forming part of Letters Patent No. 4,807, dated October 3, 1846.

To all whom it may concern:

Be it known that I, RÉNÉ L'ANGLAIS, of Paincourtville, Assumption county, State of Louisiana, have invented a new and Useful Electrical Conductor, which is described as follows, reference being had to the annexed drawings of the same, making part of this specification:

Figure 1 is an elevation of the conductor. Fig. 2 is a plan of one of the glass isolators. Fig. 3 is a vertical section of ditto.

A represents the frame for supporting the conductor and isolators. This frame is made of metal in the form represented in Fig. 1 or of any suitable and convenient form, and is secured to the top of the roof by screws, bolts, or other fastenings.

B are the cylindrical glass isolators placed in the frame for sustaining the conductor in its proper position. Each isolator is made with a cylindrical opening in the center of greater diameter than the conductor, which passes through said opening without touching any part of the isolator. A recess, B^2, is formed in the upper end of the isolator to receive a pin or arm, D, of a non-conducting material, that passes through the rod or conductor at right angles thereto, and which sustains the upper sections of the conductor in a vertical position and prevents the conductor from touching the isolator. The lower end of the isolator is reduced in diameter to form shoulders B^3, to rest upon the horizontal bars A^2 of the frame.

C represents the conductor. This conductor is made of several kinds of metals. The upper part, c', is made of platina, to resist the shock of the electric fluid when struck on the point. C^2 is composed of copper, to lessen the shock on the iron rod.

C^3 is the iron rod or conductor for conducting the fluid to the chain leading to the earth.

C^4 is the chain or conductor.

The sections c' c^2 c^3 are united by dowel-pins P, let into corresponding holes bored in the ends of the sections represented by dotted lines.

D are the arms that pass at right angles through the conductor, and which rest in the recesses of the isolators aforesaid, for supporting the rod or conductor in the centers of the openings in the isolators.

B^4 is an isolator for sustaining the lower section of the conductor and preventing it from touching the roof.

What I claim as my invention, and desire to secure by Letters Patent, is—

The manner of constructing the glass isolators with shoulders and cylindrical recesses, in the manner and for the purpose above described, in combination with the frame and rod constructed as above set forth.

RÉNÉ L'ANGLAIS.

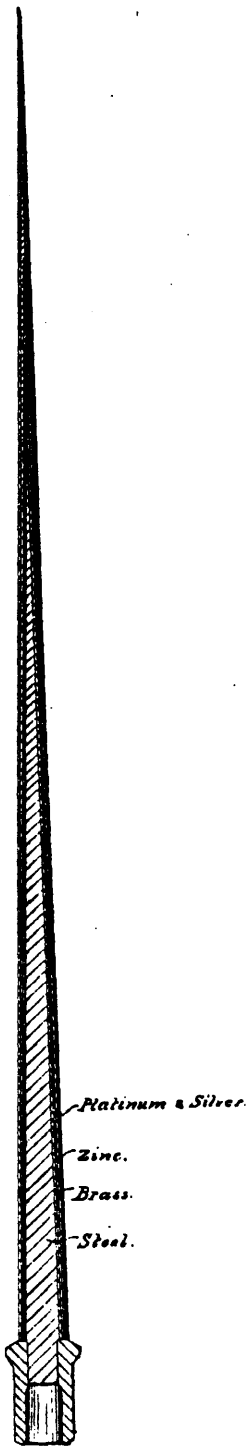
Witnesses:
WM. P. ELLIOT,
A. E. H. JOHNSON.

AETHERFORCE

J. SPRATT.

Lightning Rod.

No. 8,930. Patented May 4, 1852.



ÆTHERFORCE

UNITED STATES PATENT OFFICE.

JAMES SPRATT, OF CINCINNATI, OHIO.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. 8,930, dated May 4, 1852.

To all whom it may concern:

Be it known that I, JAMES SPRATT, of Cincinnati, in the county of Hamilton and State of Ohio, have invented new and useful Improvements in the Points of Lightning-Rods, of which the following is a specification.

The object of my improvements is to provide against the destruction of lightning-rod points by melting, as they not unfrequently do, from the sudden overcharge of the electric current.

Having, in the course of several years' experience in the manufacture and setting up of lightning-rods, frequently observed instances of destruction of the points by lightning, and recollecting that some time previous a point formed of successive layers of iron, brass, and tin, which I had set up in an isolated position for experiment, being soon after struck by lightning, the outer covering of tin melted off, leaving the brass entirely unaffected; and subsequently, during the same season, receiving another shock, the brass was melted off from the iron, which, in its turn, was also left entire, I was led to the plan of forming my points of a number of metals incased one within another, the most fusible to the outside. The effect of this arrangement is that the fusing action of an excessive shock of lightning is confined to the outer metallic layer or coating, which in flowing may be said to carry the electric fluid with it, or rather perhaps it receives in the act of melting an accession to its conducting powers; but whatever may be the true scientific solution of the phenomenon, the fact is demonstrated by experience that after the melting of one layer the next below it is left unscathed and perfect. Thus, by means of a sufficient number of layers—say from three to four—a point may be made capable of surviving as many extraordinary shocks as any one point is likely to encounter, at least during the existence of any kind of rod such as now in use.

The number of layers may vary from two to three, or upward, according to the desired completeness of the instrument, but the following I have found suitable: The innermost point may be of steel, which may be incased in brass, the brass in zinc, and, lastly, the zinc may be coated with the alloy of platinum, silver, &c., formerly patented by me, which is a superior conducting medium, and capable of receiving and preserving a high finish. Each layer should be about from one-sixteenth to one-eighth of an inch thick, and may be cast onto the preceding one.

In the annexed drawings the rod is shown in section, manufactured as above described.

Having thus fully described the nature of my improvement, what I claim therein as new, and desire to secure by Letters Patent, is—

The formation of the point of a lightning-rod, of three or more metals, incased one within another, the most fusible to the outside, in order to prevent the destruction of the entire point by melting from an overcharge of the electric fluid.

In testimony whereof I have hereunto set my hand before two subscribing witnesses.

JAMES SPRATT.

Witnesses:

GEO. H. KNIGHT,

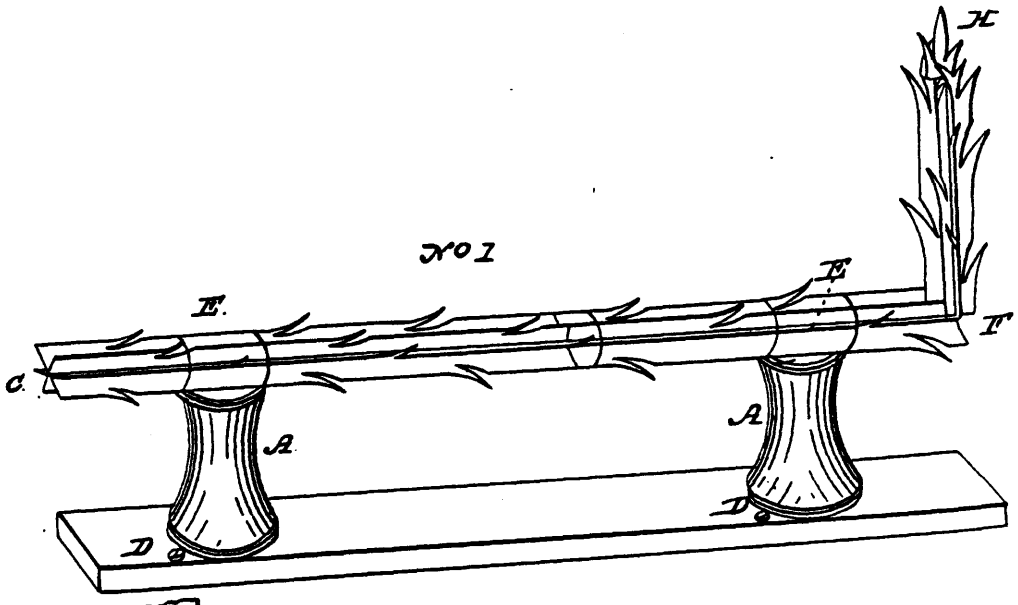
EDWARD H. KNIGHT.

ÆTHERFORCE

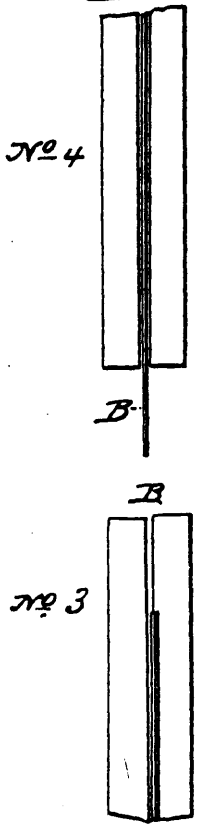
A. LYON.

Lightning Rod.

No. 11,261. Patented July 11, 1854.



№ 1



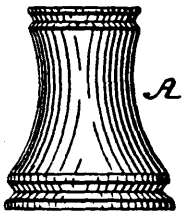
№ 4

№ 3

№ 5

№ 6.

№ 7



№ 2

Amos Lyon.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

AMOS LYON, OF WORCESTER, MASSACHUSETTS.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **11,261**, dated July 11, 1854.

To all whom it may concern:

Be it known that I, AMOS LYON, of Worcester, in the county of Worcester and State of Massachusetts, have invented a new an improved mode of constructing lightning-rods and of attaching the same to buildings; and I do hereby declare the following to be a full and exact description thereof, reference being had to the accompanying drawings, and the letters of reference marked thereon.

The nature of my invention consists, mainly, in the use of sheet-copper (on other metals to produce the same result) made in such a form for a lightning-rod as to present to the electrical atmosphere a proportionally large amount of surface with but a smaller amount of metal than is ordinarily used for the same purpose.

To enable others to make use of my invention, I will proceed to describe its construction and the manner of adjusting the rod to buildings.

I take sheet-copper about the thickness of sheathing or wash-boiler copper, five feet long, more or less, and cut it into strips three-fourths of an inch wide, or according to the size rod I wish to make, one of which I leave in a flat form, as may be seen in the accompanying drawing No. 6. The other two I bend (in a machine for the purpose) at their center lengthwise to an angle of sixty degrees, an end view of which may be seen at No. 5. The two, when bent, I solder, the one upon one side of the flat piece, in spots about six inches apart, and the other upon the other side thereof, in the same manner as represented in drawing No. 7 at letter C. When thus put together six continuous edges are presented equidistant from each other.

This rod is made continuous throughout its entire length, when adjusted upon a building, by letting the ends lap in the manner represented in drawings Nos. 3 and 4 and letters B B. An opening being left in No. 3 and a tongue upon the end of No. 4, when put together may be fastened by a wire, as is seen in drawing No. 1 at letter B. Throughout the entire length of this rod I cut in upon its edges, with shears, in such manner that needle-like points are presented in different directions, as may be seen in drawing No. 1, from letters H to C. The points are intended to receive or break up the force of a current of electricity in its passage to or from the earth.

In adjusting this rod to buildings where the case requires it to be bent, I cut in upon opposite sides sufficiently near each other and deep enough to enable me to bend as I please. (See drawing No. 1 at letter F.) I attach this rod to buildings by the use of blocks of lignumvitæ wood as non-conducting mediums, made in the following manner: I turn them out in a bell form about one and three-fourths inch in length, leaving the base about one and a half inch and the other end about one inch. Near each end I cut a groove of suitable size to admit of a wire fastening once or more around. (See drawing No. 2, as also No. 1 at letter D.) In winding on this wire I have a pin upon opposite sides of the block, around which I form the eye for a nail or screw with which to fasten it to the building. At the smallest end of the block I wind a double wire and twist it on opposite sides, then pass the two wires around the rod and twist firmly to the same. (See drawing No. 1 at letter E.) These blocks I place about five feet apart, or as often as may be required to sustain the rod.

What I claim as my invention, and desire to secure by Letters Patent, is—

The metallic surface lightning-rod made in the form herein described, or in any and every form where sheet-copper, sheet brass or iron, (either of which may be coated with metal or not,) and where the surface is all or nearly all exposed to the electrical atmosphere, and is adapted to present points upon its edges throughout its entire length, according to the mode herein described.

AMOS LYON.

Witnesses:

DARING A. WOOD,

LEWIS C. MUNN.

ÆTHERFORCE

BALDWIN & PARKS.

Lightning Rod.

No. 25,077. Patented Aug. 9, 1859.

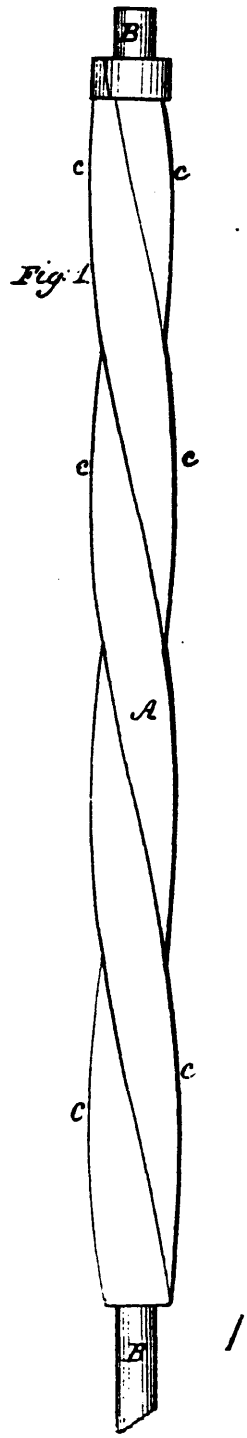


Fig. 1

Fig. 2.

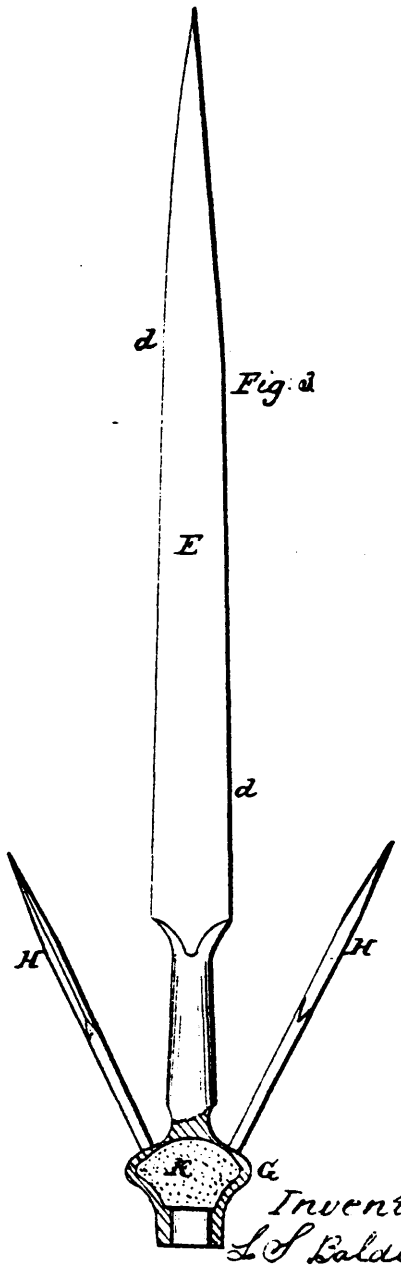


Fig. 3

Inventor;
L. S. Baldwin
Lucius Parks

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UNITED STATES PATENT OFFICE.

L. S. BALDWIN AND LUCIUS PARKS, OF LE ROY, NEW YORK, ASSIGNORS TO L. S. BALDWIN.

IMPROVED CONSTRUCTION OF LIGHTNING-RODS.

Specification forming part of Letters Patent No. **25,077**, dated August 9, 1859.

To all whom it may concern:

Be it known that we, L. S. BALDWIN and LUCIUS PARKS, of Le Roy, in the county of Livingston and State of New York, have invented certain new and useful Improvements in the Construction of Lightning-Rods; and we do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, in which—

Figure 1 represents a vertical elevation of a portion of our rod; Fig. 2, a cross-section thereof; Fig. 3, an elevation of points and section of the bulb K; Fig. 4, a plan view of the same.

Similar letters refer to corresponding parts in all of the figures.

To construct our rod we take a piece of sheet-copper of suitable dimensions, and shape it by passing it through a machine for the purpose into a quadrangular tube of the required size, say, about one-half or five-eighths of an inch. A second operation by machinery converts its plane faces into concave or fluted sides A, Fig. 2. It is then twisted till it assumes the spiral form shown in Fig. 1. It is then slipped over an iron rod, B, of a size just sufficient to fill the aperture, which may be seen through its center, and which is apparently round, as the eye follows into its depths, the interior or convex surfaces of the fluted sides forming a continuous spiral bearing on the surface of the rod. This secures great strength and stiffness to the combined rod, the four angles *c* of the tube, together with its concave sides, which bear against the iron, acting as braces to the interior rod, the two mutually strengthening each other.

The space between the rod and its shank at each of the angles serves to give a greater superficial area to the conducting capacity of the copper, while, should that prove insufficient for the amount of electricity present, the iron, as the next best conductor, will receive the surplus.

In joining the pieces of the copper tubing, one end is slightly enlarged to receive that of the next piece, while the rod B, by extending through both, prevents the point from becoming disconnected. If joints are required in the inner rod they should occur at points intermediate between those of the copper.

Our principal point consists of a triangular dart, E, the edges of which *d d*, Fig. 4, are made prominent by fluting the sides. It is composed of copper, the surfaces being plated with silver, and that part constituting the point with gold. Below the dart, near its place of connection with the rod, a bulb, G, is provided, which is hollow, and filled with a powerful loadstone magnet.

In the upper surface of the bulb are inserted the auxiliary points H, three in number, their direction diverging from the main point E, and their position relative to it equidistant between the angles *d*, so as to bring their line of attraction to act intermediately, or upon a different field from that of the edges *d*. They are made of steel, and become magnetized from being in contact at their lower ends with the magnet K, thus combining the influence of magnetism with the arrangement of the triple-edge pointed dart E and auxiliary darts H, for presenting the most complete range of attraction to the electrical atmosphere. Experiment proves that a greatly-increased power of attraction is attained by these means.

The interior rod, B, is inserted in the socket M, which is made sufficiently long to afford a secure fastening, by which it is brought in contact with the copper conducting-tube A.

The whole combined forms a remarkably strong and efficient rod, and is cheaply made, and can be put together with unusual facility.

We am aware that a patent was granted March 30, 1858, on the invention of Oren White, consisting of iron wires enwrapped by sheet-copper, and this we do not claim; but we believe our method herein described is an improvement on said plan, both as regards the greater stiffness, as well as unobstructed conducting-surface in the space formed by the angles *c c*, with a less amount of material. Therefore

We claim—

The employment of a quadrangular tube of sheet metal with spiral-fluted sides A, in combination with the straight central supporting-rod B, substantially in the manner and for the purposes herein set forth.

L. S. BALDWIN.
LUCIUS PARKS.

Witnesses:
E. C. ALLEN,
I. M. FOREMAN.

ÆTHERFORCE

I. JOHNSON.

Lightning Rod.

No. 47,310. Patented April 18, 1865.

Fig. 1.

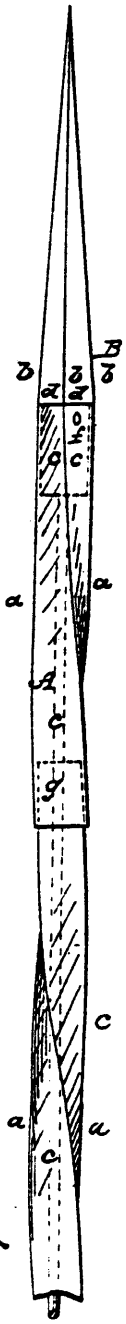


Fig. 2

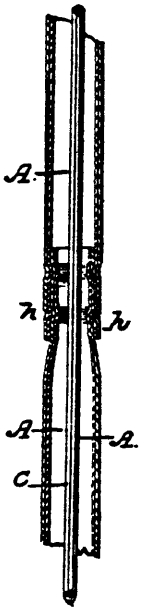
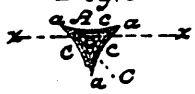


Fig. 3



Witnesses
J. Brown.
S. W. Wood

Inventor
Isaac Johnson

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UNITED STATES PATENT OFFICE.

ISAAC JOHNSON, OF LODI STATION, ILLINOIS.

IMPROVEMENT IN LIGHTNING-CONDUCTORS.

Specification forming part of Letters Patent No. **47,310**, dated April 18, 1865.

To all whom it may concern:

Be it known that I, ISAAC JOHNSON, of Lodi Station, in the county of Kane and State of Illinois, have invented a new and Improved Lightning-Conductor; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, making part of this specification—

Figure 1 being a side elevation of the upper end of a lightning-conductor constructed in my improved manner; Fig. 2, a longitudinal section of the conductor through the joint of two of the contiguous lengths of which the conductor is composed; Fig. 3, a cross-section of the conductor through one of the joints.

Like letters designate corresponding parts in all of the figures.

In the construction and application of lightning-conductors there are several important requisites, of which the most essential are, sufficient conducting capacity, the utmost dispersive capability, continuity of proper shape throughout the entire length, the most surface and least weight consistent with compactness and conducting power, the necessary strength, rigidity, and durability, cheapness and readiness of construction, portability and convenience in putting up. The best conductor is one which best fulfills all of these requisites without effecting either to the detriment of any other. The object of my invention is to attain these advantages to the fullest extent practicable.

For the conductor I employ copper, which is the best practicable material, in sheet form, so as to obtain the required surface, sufficient in size or quantity of metal to secure the full conducting capacity, triangular in form or cross-section, whereby the best dispersive power is attained and the greatest rigidity and strength are produced of which sheet metal forming a tube is capable. The sides are also made more or less concave or arching inward, so as to render the angles more acute and increase the strength; and to complete the requisite of strength, as well as to furnish the best means of uniting the whole together, I extend an iron wire through the entire length, or through such portions as may require it, inside of the triangular tube.

The use of copper formed into an angular tube with an iron rod in the middle is not new in the several particulars here mentioned, different previous inventions showing one or more of them; but the triangular form, especially when including therewith these enumerated features before separately known, produces a combined result of construction and effect not before accomplished within my knowledge; and I will proceed to point out wherein I propose to have produced novelty of invention and superior usefulness of purpose thereby in all respects consistent with one another.

As shown in the drawings, I construct the tube A of strips of sheet-copper, folded by a suitable machine or otherwise into a triangular tube, and the tube may be made of a single thickness of the sheet of copper, going once around, or of two thicknesses, the second folded in succession over the first or inner thickness, as shown in Figs. 2 and 3, or of a greater number, if desired. The angles *a a a* are made as sharp as practicable, and to increase the acuteness thereof I bend or arch the sides *c c c* of the tube inward toward the center, as shown in Fig. 3. This arched or concave form also renders the cavity of the tube much smaller, so that a small wire, C, is passed through it and fills it to the middle of the sides. and although it fits loosely in the tube, so as to be readily inserted and withdrawn, the inwardly-arched sides, whenever there is a tendency to bend or crush the rod, bear against the wire, thereby sustaining the shape and securing comparatively great strength and rigidity. This effect is much greater with the triangular than with any other possible form, for not only is the effect due to the arching as great as in any other form, but one angle is always in the direction of the strain and resists it by a triangular brace, the strongest possible. A spiral twist is generally given to the tube A, as indicated in the drawings.

The angles *a a a* of the triangle are more acute than those of any other polygonal form, and it is well known that the sharper or more acute the edges of a conductor the greater the power or facility to disperse or dissipate the electricity, and consequently the more effectual to discharge it without injurious effect to the building; but there is another principle arising

ÆTHERFORCE

from and peculiar to the triangular form of much value in increasing the dispersive power of the conductor, and, besides, it is believed, increasing the conducting capacity of the rod. This is the greatly-increased effect of induction produced by the triangular form, or, by whatever theory the induction of electricity is explained, whether of positive and negative states or quantities of one fluid or of two kinds of electricity, the fact is the same, that whenever there is an excess or tension of electricity in anything or part of anything there is always the opposite electric state produced in neighboring or opposite things or parts of the same thing; hence, with the triangular form, since each angle is opposite to the middle of a side, the full inductive effect is produced without diminishing or neutralizing the tension at the other angles of the conductor, whereas, with the quadrangular or any other angular form of conductor except the triangular, one angle is always exactly or more nearly opposite to another angle, so that one more or less neutralizes the action of the other and a less tension or quantity of the electricity is possible. This increased tension in the angles of the triangular form increases the dispersive action of the electricity, and there appears reason to believe that the whole conductor is thereby rendered capable of conducting a greater amount of electricity, under similar circumstances, than other forms of conductor of equal quantity of metal and extent of surface. Then, the triangular inwardly-arched form, by giving a smaller internal cavity and requiring a smaller rod or wire, C, than the quadrangular or any other form of a greater number of sides, cheapens the construction and facilitates the portability of the conductor in a peculiar manner, for, using only a simple wire of moderate size gives sufficient strength, by binding the lengths or sections of the tubular portion A of the conductor together, which are sufficiently rigid in themselves, owing to their triangular form. This wire is not only cheaper in itself than a rod, but it can be carried about in any length, coiled up or wound on a reel, and then it is readily straightened again with the hands in putting up the conductor; whereas a rod of iron of sufficient size to fit other angular forms of conductor practically cannot be coiled up, but must be carried in lengths or divisions, and the joints of rods in sections are very apt to break, which renders the rods much inferior to a continuous wire, the latter being very seldom liable to break.

The lengths or sections of the copper tube A are made a little smaller or contracted at the upper ends, as at *g*, so as to enter the lower ends of the lengths above an inch or two, and thus couple the sections together. When the rod is put up the lengths or sections are slipped or strung successively upon the wire C, their ends connected by inserting one in another, as above, and then simply indenting the lapped joints in one or two places, as indicated at *h h*, Fig. 2, with pinchers or their equivalent. Thus all rivets, screws, and soldering are dispensed with and the joints are connected all the more rapidly and with slight expense. Less obstruction to the currents of electricity is also offered in this way. The conductors, likewise, are readily taken down again and moved whenever necessary, the method of uniting the sections and the use of wire rendering them very easy to be again separated by hand.

Another advantage of the triangular form of conductor arises from its connection with the point B. The triangular is obviously the best angular form which can be given to the point, fulfilling all the requisites of the best quietly-receiving quality. The triangular form of the conductor A enables the point B to be inserted in or joined to it and have the edges *a a a* of the conductor exactly continuous with the edges *b b b* of the point, and the sides *c c c* of the conductor continuous with the sides *d d d* of the point. This secures another very good result, since it is known that a conductor which has no breaks, bends, nor obstructions in its surface is better and surer to conduct electricity than those having such defects.

The socket-shank of the point B is inserted into the upper end of the tube A, and may be secured therein by a rivet, *f*, Fig. 1, or in any other suitable manner.

The triangular form of the conductor, the best in itself, and the triangular form of the point, the best in itself, are thus combined in this conductor, and in their union a third feature of perfection is secured—that of the continuous angles and sides. No other conductor, within my knowledge, has ever so perfectly combined the best qualities of a safe lightning-conductor.

Having thus fully described my improved lightning-conductor, I wish it to be understood that I do not claim an angular nor a tubular conductor in itself, nor arching its sides, nor extending a rod through its center, separately considered; but since I show that the triangular form enhances the good effects of the other features, thus rendering the angles of a tubular conductor more acute and dispersive, and the tube stronger and more rigid, and since the central iron rod is thereby enabled to be much smaller—in fact, a mere wire—thus rendering it cheaper, lighter, and more portable, and in one piece—

What I claim as my invention, and desire to secure by Letters Patent, is—

A lightning-conductor composed of a triangular tube, A, with inwardly-arched sides, in combination with a continuous central iron wire, C, extending partly or wholly through the length of the tube, substantially as and for the purposes herein set forth.

The above specification of my improved lightning-conductor signed by me this 20th day of December, 1864.

ISAAC JOHNSON.

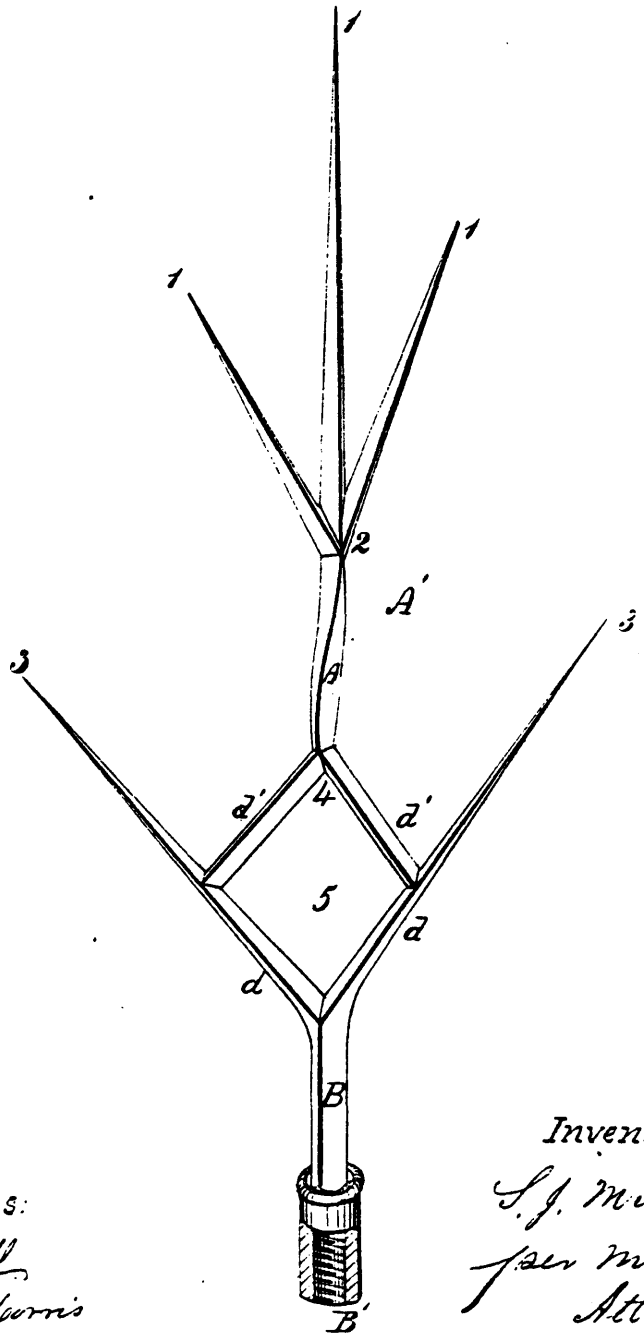
Witnesses:
J. S. BROWN,
S. W. WOOD.

ÆTHERFORCE

S. J. MITCHELL.

Lightning Rod.

No. 47,846. Patented May 23, 1865.



Witnesses:

C. L. Topliff

Henry Morris

Inventor:

S. J. Mitchell

per Munn & Co

Attorneys

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

S. J. MITCHELL, OF ST. LOUIS, MISSOURI.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **47,846**, dated May 23, 1865.

To all whom it may concern:

Be it known that I, S. J. MITCHELL, of St. Louis, in the county of St. Louis and State of Missouri, have invented a new and useful Improvement in Lightning-Rods; and I do hereby declare that the following is a full, clear, and exact description thereof, which will enable those skilled in the art to make and use the same, reference being had to the accompanying drawings, forming part of this specification.

The drawing, consisting of one figure, represents a lightning-rod constructed after my invention.

The object of my invention is to produce a lightning-rod which will conduct the fluid with more certainty to the conductor or main rod, while it also presents a great number of attracting-points or a large attracting-surface without enhancing the difficulties of construction or the cost.

A′ represents the head of a lightning-rod, fitted in its hollow base B′ with a screw-thread, by which it is to be secured to the main conducting-rod. (Not shown.) The base B′ is shown in section in the figure.

The stem B extends for a little distance above its base, when it divides into two branches, *d*, which diverge on opposite sides of the axis of the stem B at an angle therewith of about forty-five degrees, terminating in attracting-points 3. Two bars, *d′*, spring from the upper sides of these branches at points whose distance above the stem B is equal to about one-third of their length. The bars *d′* extend in lines at right angles with the branches from whose sides they spring, respectively, until they meet at a point marked 4, where they unite with the main point A of the head A′. The main point A is continued a little distance to the height indicated by 2, where it is divided into branches 1 of unequal heights, which diverge so as to give the best attracting-surface to the point.

It will be observed that the stem B and the other parts of the head A′ are rhomboidal in cross-section, and that the main point A, between the points marked 4 and 2, is slightly twisted. The space inclosed within the branches and bars *d d′* is also rhomboidal in shape.

The figure represents the head A′ of the lightning-rod in perspective at an angle of about forty-five degrees with the plane of observation, in order to show at the same view the mode of connecting the stem B with the main point A and the divergence of the upper branches 1. If seen in front elevation, the upper branches 1 would form one line to the eye, for the reason that the lesser and outer branches 1 diverge from the inner and vertical branch 1 in a plane which is at right angles with the plane of the branches *d* and bars *d′*. The result of this construction is to present the attracting-points 3 and the lesser branches 1 on opposite sides of the head A′, or in planes at right angles to each other.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

The separation or division of the main point A into two bars, connecting by means of branches *d* with the stem B of the rod, substantially as described.

S. J. MITCHELL.

Witnesses:
DAVID P. HULL,
WM. F. COZZENS.

ÆTHERFORCE

A. S. SHERWOOD.

Lightning Rod.

No. 52,329. Patented Jan. 30, 1866.

Fig. 1

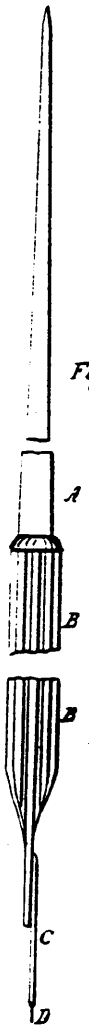


Fig. 2

Fig. 3

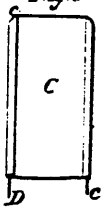


Fig. 4

Witnesses

E. Schmidt

J. L. Pigeon

Inventor

A. S. Sherwood

By Baldwin & Son

Attys.

UNITED STATES PATENT OFFICE.

A. S. SHERWOOD, OF DETROIT, MICHIGAN.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **52,329**, dated January 30, 1866.

To all whom it may concern:

Be it known that I, A. S. SHERWOOD, of the city of Detroit, in the county of Wayne and State of Michigan, have invented a new and useful Improvement in Lightning-Rods; and I do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same, reference being had to the annexed drawings, making a part of this specification, in which—

Figure 1 shows the top and point of a lightning-rod broken, but exhibiting its connection with my improvement. Fig. 2 represents a view, in cross-section, of the corrugated circular portion of the rod. Fig. 3 shows a part of the rod in elevation, and Fig. 4 is a cross-section through the same.

It is believed to be conceded by electricians that conduction is in proportion to mass and surface, and that none but the precious metals are better conductors of electricity than copper. To use with proper economy copper conductors it is desirable to make them as light as may be found consistent with proper strength and durability, and narrow strips of copper made in the shape of plain ribbon, have therefore been used as lightning-rods, thereby securing the largest surface proportioned to mass; but this plain ribbon is objectionable because fragile, and it is the object of my invention to remedy this defect by making lightning-rods or conductors of electricity of sheet-copper with a corrugated circular top, and to stiffen and strengthen the narrow ribbon portion of the rod without increasing its width; and my invention consists in corrugating thin sheet-copper and forming the portion of the lightning-rod that receives the point and projects above the building into a tube, which is securely attached to the remainder of a lightning-rod made of thin sheet-copper ribbon turned over on a copper wire at its edges, or on itself, and thus augment the surface and mass of the rod without increasing its width. By this I accomplish these several desirable results—viz., first, the use of the thin sheet-metal possessing the greatest conductive capacity, (silver excepted;) second, obtaining the greatest possible amount of surface to the least possible amount of metal; third, increasing the strength and stiffness of the ribbon without diminishing the surface or materially increasing its weight; fourth, attaining a finish and symmetry in its construction which can be obtained in no other way.

Taking thin sheet-copper, I corrugate a strip wide enough to receive the top or platinum point A when formed into a tube, B, and this I make as long as the rod is to project above the building to which the rod is to be attached. I fasten the point A securely within the top of the corrugated tube B, and at the bottom I flatten the tube and attach it securely, by rivets or otherwise, to the portion of the rod C which is to enter the ground. Thus I make my rod of a single length of narrow copper ribbon and fasten it in place in any approved manner. But to stiffen the ribbon and increase its mass without using heavy sheet-copper or making the conductor any wider than is necessary, I turn the edges *c* and *c'* over upon the ribbon, or over and around a copper wire, D, so as to embrace the whole circumference of the wire and hold it firmly.

What I claim as my invention, and desire to secure by Letters Patent, is—

The combination of the turned or wired copper ribbon with the corrugated tubular top, substantially as and for the purpose described.

In testimony whereof I have hereunto subscribed my name.

A. S. SHERWOOD.

Witnesses:
RALPH C. SMITH,
W. S. PENFIELD.

AETHERFORCE

L. J. HAWLEY.

Lightning Rod.

No. 52,411. Patented Feb. 6, 1866.

Fig. 1.

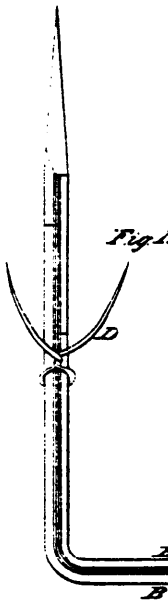
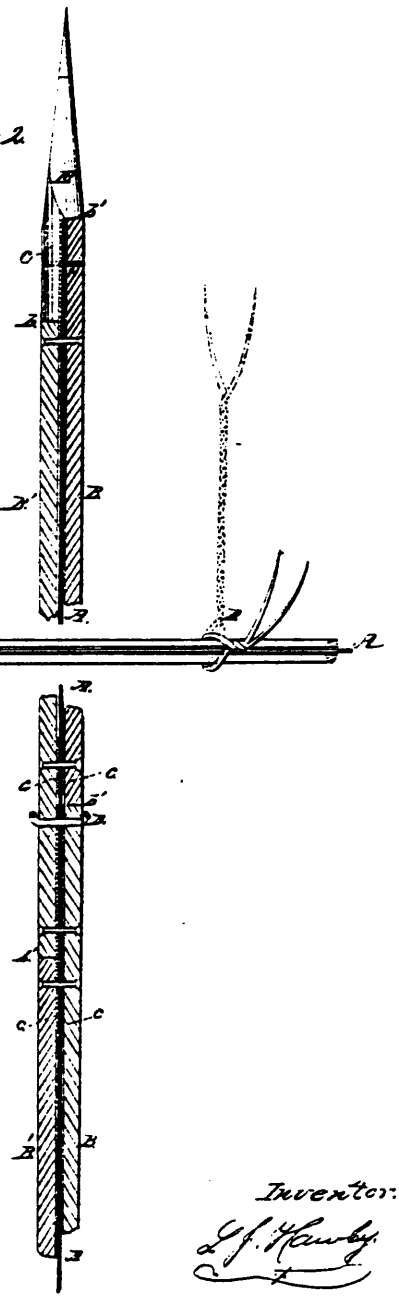


Fig. 2.



Witnesses.
Ontario Knight
Edward Knight

Inventor:
L. J. Hawley

UNITED STATES PATENT OFFICE.

LOUIS J. HAWLEY, OF BALTIMORE, MARYLAND.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **52,411**, dated February 6, 1866.

To all whom it may concern:

Be it known that I, LOUIS J. HAWLEY, of the city and county of Baltimore, and State of Maryland, have made new and useful Improvements in Lightning-Rods; and I do hereby declare the following to be a full, clear, and exact description of the nature, construction, and operation of the same, sufficient to enable one skilled in the art to which it appertains to construct and use the same, reference being had to the accompanying drawings, which are made part of this specification, and in which—

Figure 1 is an elevation. Fig. 2 is a vertical central section.

The invention consists in the arrangement and mode of attachment of the metals of which the rod is composed, and in utilizing the ends of the wires whereby the metals are tied together as supplementary conductors distributed along the length of the rod.

The rod is made in sections of any suitable length—say ten feet—and consists of a central copper strip, A, of that length inclosed between two pieces of half-round or half-oval iron, B B′. The inclosing iron rods B B′ are so prolonged, one at each end, as to make a splice-joint, (shown at *b b′*,) where one section is attached by a lap-joint to the next section, whether it be the point or another section of the same character as itself. This lap may extend about three inches, more or less.

The two iron bars and their inclosed strip are fastened together by rivets C C, and by wires D D, which are passed through holes in the metal rods and strips, and, being twisted, are afterward prolonged and pointed, projecting from the rod so as to act as conductors to increase the protective power of the rod.

Between the iron and the copper is interposed a layer of zinc at all the places where by rivet C or wire D the parts are joined, the intention of which is to separate and expose the surfaces of the bars and induce a galvanic action in the rod by placing the best conductor in the center supported by side conductors. By this arrangement the central strip may conduct a positive charge, while the side strips may discharge a negative or assist in diffusing a heavy charge of either, the combined rod affording a very large amount of conducting-surface within the limited diameter and equal at the splices to any other part, while the zinc at the connections preserves the rod in good condition by the galvanic action induced.

The point E, of plated copper, is lapped by its shank upon the upper section of the rod and attached thereto, and the rod is secured in any suitable manner to the building.

Having described my invention, what I claim therein as new, and desire to secure by Letters Patent, is—

1. The lightning-rod constructed as described and represented, consisting of a central copper strip inclosed between lap-joint iron side pieces, the points of connection being provided with interposed zinc plates.

2. The supplementary conductor formed by the points of the prolonged wire band D D, as described and represented.

The above specification of my improvement in lightning-rods signed this 28th day of August, 1865.

L. J. HAWLEY.

Witnesses:

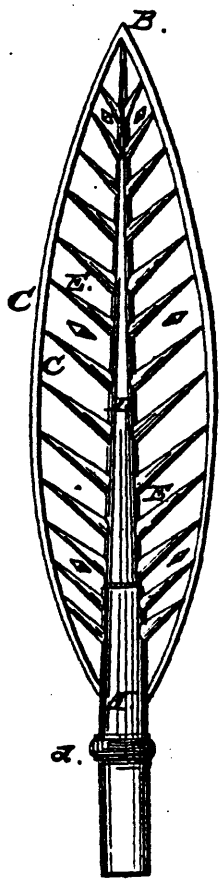
ALEX. A. C. KLAUCKE,
OCTAVIUS KNIGHT.

ÆTHERFORCE

J. F. BOYNTON.

Lightning-Rod Point.

No. 96,194. Patented Oct. 26, 1869.



Witnesses

W J Green

Geo C Larrbright

Inventor.

John F. Boynton

ÆTHERFORCE

United States Patent Office.

JOHN F. BOYNTON, OF SYRACUSE, NEW YORK.

Letters Patent No. 96,194, *dated October* 26, 1869.

IMPROVEMENT IN LIGHTNING-ROD POINTS.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that I, JOHN F. BOYNTON, of the city of Syracuse, county of Onondaga, in the State of New York, have invented a new and improved point for a lightning-rod, designated as Boynton's Lightning-Rod Edged Point; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon.

The nature of my invention consists of a lightning-rod tip, so constructed that it can be struck with a die from a piece of plate or sheet-metal, and so corrugated as to increase its surface, and give strength and stiffness to the material. It is shaped somewhat as a spear-head, with an edge, which acts as an extended point, and is continued around from the point unto the hilt, tube, or ferrule, which connects it with the rod. It is provided with one or more corrugations, elevated or depressed, which may run longitudinally, and with others diverging at different angles toward or unto the edge, thereby giving to the edge a plain or zigzag condition, and increasing the surface of the plate, the whole presenting much the appearance of the vertebræ and ribs of a fish.

A is the ferrule, tube or hilt of the corrugated spear-point of a lightning-rod.

B, the point of the spear-head.

C C, edges.

D, longitudinal corrugations.

E E, lateral alternating corrugations.

d is the ring which holds the halves of the spear-ferrules together, by being milled or soldered.

I am aware lightning-rod points have been made in various ways and forms; but

What I claim as my invention, and desire to secure by Letters Patent, is—

1. A lightning-rod point, with compound corrugations, and constructed as above described.

2. The compound corrugated point, combined with a swaged ferrule or tube, for connecting it with the rod.

Witnesses: JOHN F. BOYNTON.

T. C. CONNOLLY,

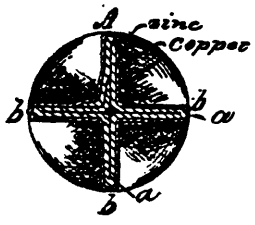
H. GARRETT.

ÆTHERFORCE

REYBURN & MARTIN.

Lightning Rod.

No. 96,268. Patented Oct. 26, 1869.



Witnesses:

C. A. Petits

J. C. Kemon

Inventors:

Reyburn and Martin

by Munn & Co

Attorneys

ÆTHERFORCE

United States Patent Office.

WILLIAM S. REYBURN AND F. J. MARTIN, OF PHILADELPHIA, PENNSYLVANIA.

Letters Patent No. 96,268, *dated October* 26, 1869.

IMPROVEMENT IN LIGHTNING-RODS.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that we, WILLIAM S. REYBURN and F. J. MARTIN, of the city and county of Philadelphia, and State of Pennsylvania, have invented a new and useful Improvement in Lightning-Rods; and we do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same, reference being had to the accompanying drawings, making a part of this specification, in which the figure is a plan view of the end of the rod.

This invention is an improvement upon the patent granted to Vermilya, Reyburn, and Hunter, July 13, 1869. That patent was for a rod formed of a copper covering upon a rolled iron centre.

This invention consists in combining a sheet-copper covering, constructed in a peculiar manner, with a sheet-zinc centre, similarly contrived, whence certain advantages result, as hereinafter fully set forth.

In the drawings—

A is a lightning-rod, of the kind produced by Reyburn and Martin's rod-forming machine, patented August 17, 1869.

The rod A is made up of a sheet-zinc centre, *a*, and a sheet-copper covering, *b*.

The superiority of a sheet-zinc centre over a rolled iron one lies in this: that the zinc, while it affords, in connection with a copper covering, sufficient strength for a first-class rod, costs about fifty per cent. less than iron; that it has twice the power of conducting electricity; that it is non-corrosive; and that, when combined with copper as a covering, on the introduction of sufficient moisture from the atmosphere, the earth, or rain, a chemical action is produced, which goes toward the preservation of the copper, and increases the conductivity of the rod, by producing a constant current of electricity.

The centre *a* and the covering *b* are both formed of sheet-metal, doubled upon itself in ribs, as described in the said Reyburn and Martin patent, the centre being run through the machine first, and the covering then applied. The strength given to the rod by this formation is such that sheet-zinc—a metal naturally weak, so far as its power of enduring strains is concerned—may be manufactured into a centre possessing, with the copper covering, ample stiffness for all practical purposes.

The centre, in the Vermilya, Reyburn, and Hunter rod, is made of rolled iron, and this cannot be manufactured into a lightning-rod centre so cheaply as sheet-zinc, as any manufacturer knows; and, if sheet-iron were used to form the same kind of centre as the Reyburn and Martin rod uses, it would be necessary to galvanize it, to prevent oxidation, owing to the fact that the copper covering could not be applied to a sheet-iron centre in such a manner as to make it water-tight, as the requisite pressure would injure the ribs.

Galvanized sheet-iron would be more costly than sheet-zinc, and in no respect superior.

Having thus described our invention,

What we claim as new, and desire to secure by Letters Patent, is—

As an article of manufacture, a section of lightning-rod, composed of a sheet-zinc centre, bent upon itself in webs, and a copper covering, similarly formed, substantially in the manner and for the purpose described.

To the above specification of our improvement, we have set our hands, this 17th day of August, 1869.

WILLIAM S. REYBURN.
F. J. MARTIN.

Witnesses:
CHAS. A. PETTIT,
S. C. KEMON.

ÆTHERFORCE

G. ROW.

Lightning Rod.

No. 109,455. Patented Nov. 22, 1870.

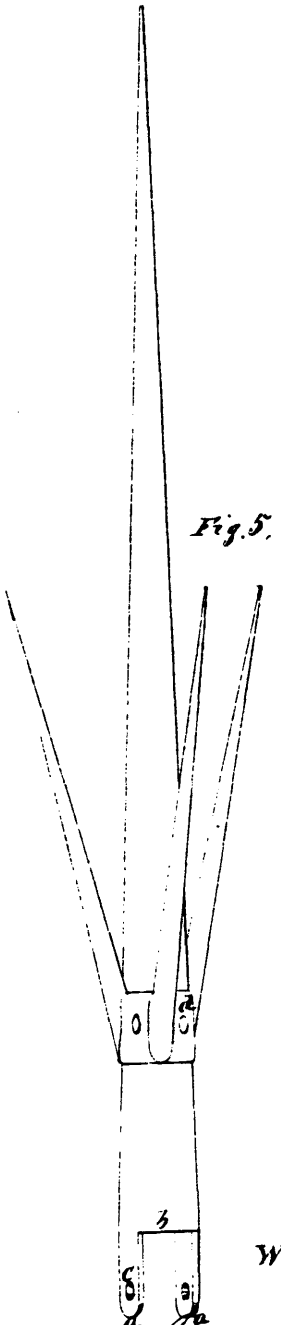


Fig. 5.

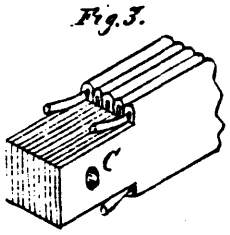


Fig. 3.

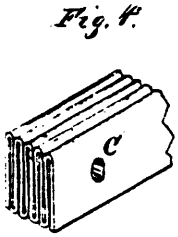


Fig. 4.

Fig 2

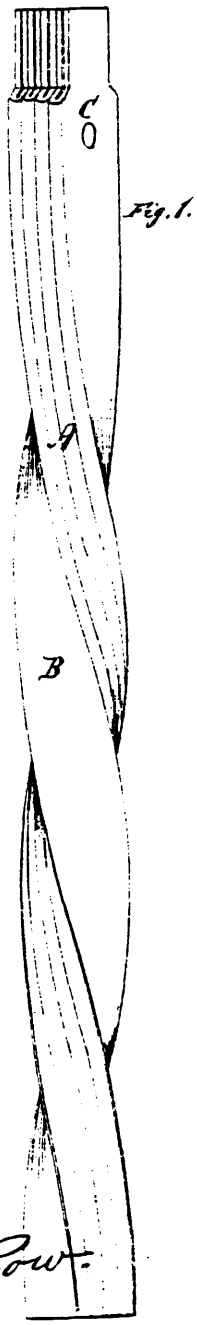


Fig. 1.

Witnesses:

Silas M. Clark.

Ira C. A. Row.

Inventor.

George Row.

United States Patent Office.

GEORGE ROW, OF INDIANA, PENNSYLVANIA

Letters Patent No. 109,455, dated November 22, 1870.

IMPROVEMENT IN LIGHTNING-RODS.

The Schedule referred to in these Letters Patent and making part of the same.

I, GEORGE ROW, of Indiana, in the county of Indiana and State of Pennsylvania, have invented certain Improvements in Lightning-Rods, of which the following is a specification.

Nature and Objects of the Invention.

The first part of my invention relates to constructing a lightning-rod of sheet-copper of convenient size in a series of plications or inverse folds or plaits running longitudinally and lightly pressed down, leaving small vacuums or spaces intervening the folds, whereby the conduction surface of the rod is largely increased, the extent of such surface being limited only by the number and breadth of the folds. The rod is also twisted spirally, adding to its symmetry and preventing the folds being opened, thereby strengthening it. The point section, or that part which may extend above the building or other object upon which it may be erected, may be further strengthened by inserting between the outer folds or leaves as many wires as shall be necessary to insure the desired result.

The second part of my invention relates to the manner, as shown, of joining together the respective pieces or sections of rod, make as above described, said joints or connections being formed by cutting away a portion of the back of the respective folds at one end of each sectional part of the rod, separating the leaves, and creating a shoulder to meet the ends of the connecting section; then, by taking the ends of the several sections of rod thus prepared, and inserting the separated leaves or folds into the interstices of the connecting section, a substantial joint is effected, which is thus fully secured by a common copper rivet.

Description of Drawing.

Figure 1 represents a sectional part of the rod, showing the several folds A, the width of the folds B, and rivet-holes for fastening joints C.

Figure 2 illustrates the sections joined, the transverse line exhibiting the point of junction with the rivet-fastening C.

Figure 3 represents the head of section with the backs or folds cut down, forming a shoulder and separating the leaves.

Figure 4 illustrates the foot of section, showing spaces between folds, into which the separated leaves, as shown in fig. 3, are inserted, forming the connections between the several sections.

Claims.

I claim as my invention—

1. A lightning-rod, constructed of a series of plications or folds of metal, substantially as and for the purposes hereinbefore set forth.

2. The manner of connecting the several sectional parts, substantially as and for the purposes hereinbefore set forth.

GEORGE ROW.

Witnesses:
SELAR M. CLARK,
CHAS. H. ROW.

ÆTHERFORCE

O. PRESTON.

Improvement in Lightning Rods.

No. 120,457. Patented Oct. 31, 1871.

Fig. 1.

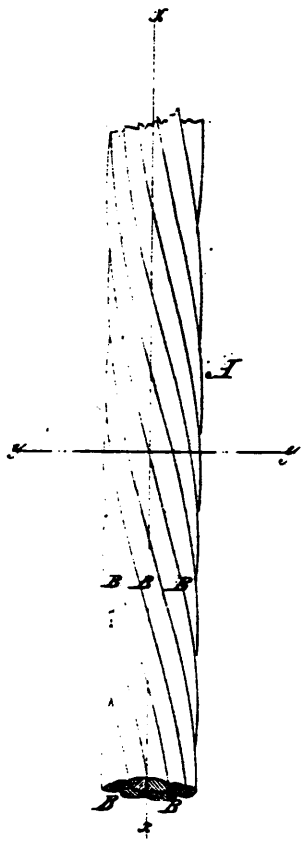


Fig. 2.

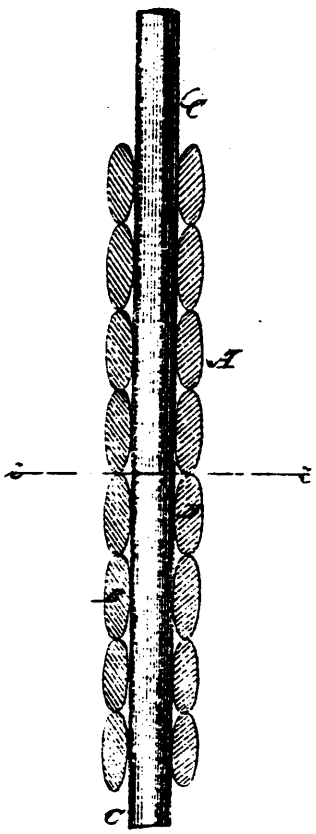
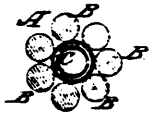


Fig. 3.

Fig. 4.



Witnesses:

Gustave Dieterich

Francis McArdle

Inventor:

O. Preston

Per Munn & Co.

Attorneys.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

OTHNIEL PRESTON, OF SOUTH DANSVILLE, NEW YORK.

IMPROVEMENT IN LIGHTNING-CONDUCTORS.

Specification forming part of Letters Patent No. 120,457 dated October 31, 1871.

To all whom it may concern:

Be it known that I, OTHNIEL PRESTON, of South Dansville, in the county of Steuben and State of New York, have invented a new and useful Improvement in Lightning-Conductors; and I do hereby declare that the following is a full, clear, and exact description thereof, which will enable others skilled in the art to make and use the same, reference being had to the accompanying drawing forming part of this specification.

This invention relates to new and useful improvements in lightning-conductors, whereby they are made more effective than they have hitherto been; and it consists in making the conductor tubular composed of a series of wires twisted together, and either with or without an inclosed metallic tube, the construction of the conductor being as hereinafter more fully described.

In the accompanying drawing, Figure 1 represents a section of a conductor constructed of wires twisted together forming a tube. Fig. 2 is a longitudinal section of Fig. 1 on the line *x x*, showing the wires surrounding a metallic tube. Fig. 3 is a cross-section of Fig. 1 taken on the line *y y*. Fig. 4 is a cross-section of Fig. 2 on the line *z z*.

Similar letters of reference indicate corresponding parts.

A represents the conductor; B, the wires; C, the interior metallic tube. The wires B are twisted together either around a solid core which is removed, or a metallic tube, C, which latter is allowed to remain; in either case a tubular conductor is formed which greatly increases the extent of surface of the conductor.

I am aware that it is contended that the conductivity of a lightning-rod is according to the area of its cross-section. My own experience, which has not been very limited in the business of manufacturing and putting up lightning-conductors, leads me to doubt the entire correctness of that theory. In practice I have found that surface has much to do with the conductivity of lightning-rods. Conductors composed of broad straps of metal having great superficial area and but slight cross-sectional area have been employed with good results. I am aware that, with a view of increasing the superficial area, conductors have been made of woven wire, and also of braided or plaited wire in the tubular form.

I disclaim all conductors constructed by either weaving, braiding, or plaiting the wire.

My lightning-conductor is made of wires twisted together around a core or tube, and is in outward form the same as a wire rope and continuous from end to end, and may be of any required length. In twisting the wires around a solid core, the core is withdrawn, which leaves the conductor tubular. If twisted around a metallic tube the tube is allowed to remain, which also leaves the conductor tubular. In either case the conductor is a tube composed of wires twisted together and having the strength and flexibility of a wire rope when made without the interior tube, but which is, of course, more stiff and rigid when made with the tube.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. The tubular lightning-conductor A, constructed of wires B twisted together, substantially as shown and described.

2. A lightning-conductor composed of wires B twisted together in the tubular form inclosing a metallic tube, C, substantially as shown and described.

3. A tubular lightning-conductor, constructed of wires twisted together either with or without an inclosed metallic tube.

The above specification of my invention signed by me this 2d day of August, 1871.

OTHNIEL PRESTON.

Witnesses:
GEORGE W. MABEE,
T. B. MOSHER.

(50)

ÆTHERFORCE

D. F. WELSH.

Improvement in Lightning Rods.

No. 123,958. Patented Feb. 20, 1872.

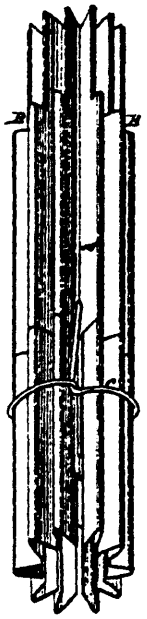


Fig 1.

Fig 2.

Fig 3.

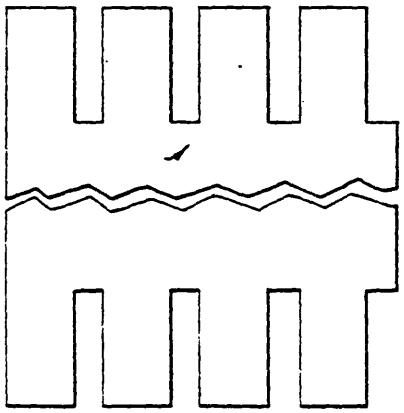


Fig 4.

WITNESS.

J. N. Goodbread
E. F. Elliott

INVENTOR.

Dwight F. Welsh

ÆTHERFORCE

123,958

UNITED STATES PATENT OFFICE.

DWIGHT F. WELSH, OF NEVADA, OHIO.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. 123,958, dated February 20, 1872.

SPECIFICATION.

I, DWIGHT F. WELSH, of Nevada, in the county of Wyandot and State of Ohio, have invented a certain new and Improved Lightning-rod, of which the following is a specification:

This invention relates to the construction of a lightning-rod of sheet metal, bent in a corrugated form, and then uniting the edges so as to form a corrugated or fluted column or rod, in which a greater amount of surface is gained for conducting the electric fluid. It also relates to the method of uniting the sections of the rod, whereby the same may be made continuous to an unlimited extent.

The following description fully sets forth the construction and objects of my invention.

In the drawing, Figure 1 is an elevation or side view, and Fig. 2 is an end view of the rod. Fig 3 is an end view of a corrugated sheet. Fig. 4 represents the manner of slotting the ends of the sheets for the purpose of uniting the sections.

A in the several figures represents sheets of metal, (copper is preferable, but any suitable metal may be used,) which are passed through a forming-machine, and bent in a corrugated form, as seen in Fig. 3, the ends of the sheets having been previously cut with slots, as seen in Fig. 4. The object of said slots will be hereinafter shown. The sheets are then turned so as to bring their side edges *b b* together, and are then united with solder or any other suitable means, the end appearance of the said sheet being that of a star, as seen in Fig 2. By cutting the ends of the sheets into slots, as aforesaid, and folding the sheets so as to make the folds at the slots and between the slots alternately, the ends of the rod, when folded, will have a shoulder all around, as seen at B, Fig. 1. To form a socket at each end of the rod, the sheets are folded in the opposite direction, so as to bring the slots at the inside of the rod. The shoulder then being on the inside, the socket will receive the end of the section having the shoulder on the outside. In this manner the several sections are united to form a continuous rod. To secure them together, a wire rod, C, is passed through holes near where the sections are united, and is brought together and twisted; the ends of the wire are passed around on the opposite side and are twisted together several times, securing all firmly. The sheets may also be cut with slots at either end so as to form, alternately, a socket on one end and a shoulder on the other. The sections might also be cast in molds, to form corrugated or fluted rods similar to the bent sheets, having sockets and shoulders alternately, if desired; but the method of forming the rods of sheet metal I consider the simplest and most economical method, my principal object being to produce a fluted rod having a large amount of surface in the smallest compass, for conducting electricity from buildings. I am aware that hollow fluted lightning-rods of thin metal have been manufactured before the date of my invention; but the sections of the same are formed of three or more distinct pieces, the connecting of which, to form such section, involves much labor and expense. I prefer manufacturing the sections of my rod each of a single strip of metal, as described, as the rod is stronger and more cheaply made; but two strips could be used in the construction of each section with but slight increase in labor and cost.

What I claim is—

1. A lightning-rod each section of which is formed, respectively, from one or two sheets of metal, so bent or fluted that when the side edges of such sheet or sheets are brought together and connected a hollow section of rod of stellate form is produced, as described.

2. The strips of metal so slotted at their ends that when formed into sections of rod the slots produce upon each end of the section a tongue, or a socket, or a tongue and socket, respectively, as described, for the purpose set forth.

DWIGHT F. WELSH.

Witnesses:

J. N. GOODBREAD,

E. F. ELLIOTT.

ÆTHERFORCE

J. W. HANKENSON.

Improvement in Lightning Rods.

No. 128,617. Patented July 2, 1872.

Fig. 1.

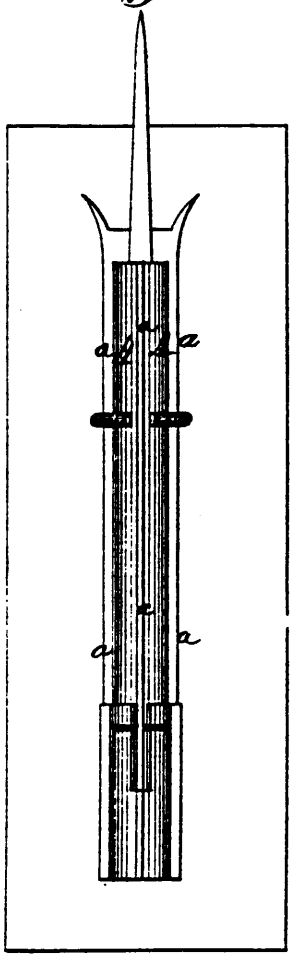
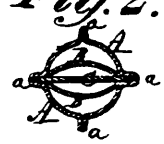


Fig. 2.



Witnesses
John A. Ellis,
Wm. K. Ellis,

Inventor
J. W. Hankenson
Per.
T. H. Alexander
Atty.

ÆTHERFORCE

128,617

UNITED STATES PATENT OFFICE.

JAMES W. HANKENSON, OF MINNEAPOLIS, MINNESOTA, ASSIGNOR TO HIMSELF AND MOHOLA BRAWLEY, OF SAME PLACE.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. 128,617, dated July 2, 1872.

SPECIFICATION.

To all whom it may concern:

Be it known that I, J. W. HANKENSON, of Minneapolis, in the county of Hennepin and State of Minnesota, have invented certain new and useful Improvements in Lightning-Rods; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawing and to the letters of reference marked thereon which form a part of this specification.

The nature of my invention consists in a copper lightning-rod made of four strips, forming an inner and an outer shell, and the inner shell provided with a center or core of zinc, as will be hereinafter more fully set forth.

In order to enable others skilled in the art to which my invention appertains to make and use the same, I will now proceed to describe its construction and operation, referring to the annexed drawing, in which—

Figure 1 represents a side elevation, and Fig. 2 a cross-section of my lightning-rod.

My lightning-rod is composed of four strips, A A and B B, of copper, the two strips A A forming an outer shell, pressed or otherwise united together so as to form projecting flanges *a a*, running longitudinally with the rod. The two strips B B form an oval inner shell, as shown, its edges being held in two opposite flanges, *a*, of the outer shell. These pieces B B add to the conductive surface of the rod, and still in a compact form. Through the inner shell B is passed a center or core, C, of zinc, forming with the copper a combination which produces galvanic action, thereby protecting the inside of the rod from verdigris or corrosion, which destroys the metal and conductive power of the rod. A center or core of zinc may be used with any copper lightning-rod for the same purpose.

Having thus fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

A lightning-rod, made of an interior and an exterior copper shell, and provided with a zinc center or core, substantially as and for the purposes herein set forth.

In testimony that I claim the foregoing as my own I affix my signature in presence of two witnesses.

JAMES W. HANKENSON.

Witnesses:
H. W. MCNAIR,
MARTIN V. PRATT.

ÆTHERFORCE

D. MUNSON.

Improvement in Lightning-Rods.

No. 129,676. Patented July 23, 1872.

Fig. 1.

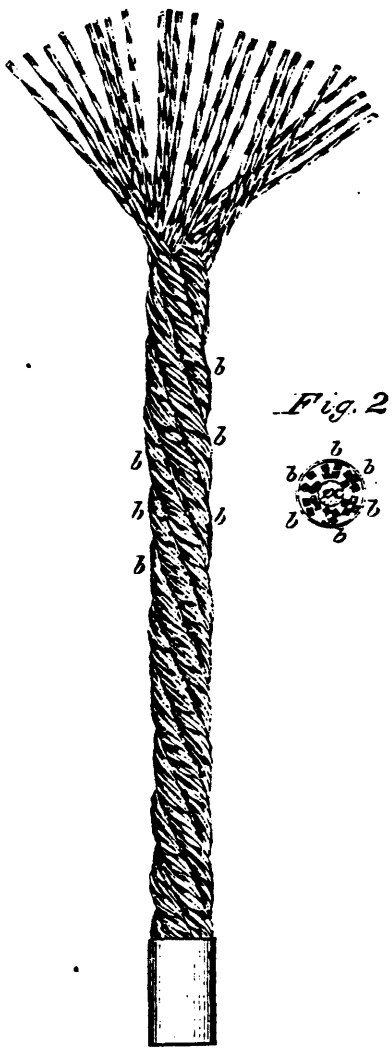


Fig. 2.

Fig. 3.

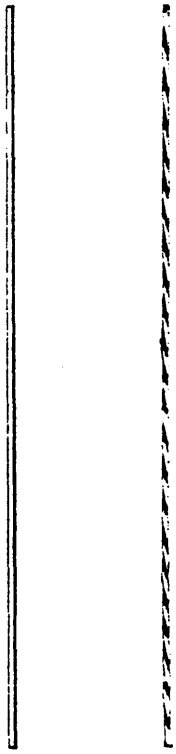


Fig. 4.

Witnesses:

T. C. Brecht.

Wm. J. Peyton.

Inventor:

David Munson

by Johnson, Kenwicke & Co.

his Attorneys

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

DAVID MUNSON, OF INDIANAPOLIS, INDIANA.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **129,676**, dated July 23, 1872.

To all whom it may concern:

Be it known that I, DAVID MUNSON, of Indianapolis, in the county of Marion and State of Indiana, have invented a new and useful improvement in Lightning-Rods, of which the following is a specification:

In the accompanying drawing, Figure 1 represents a view of a piece of my improved lightning-rod, and Fig. 2 is a sectional view of the same. Figs. 3 and 4 represent a single angular copper wire, straight, and twisted around its own axis, from the latter of which the rope is formed.

My invention consists of a lightning-rod formed of any suitable number of angular copper-wire ropes, each rope consisting of a plurality of angular copper wires, each of which angular wires is first twisted around its own axis and a number of them laid or twisted together to form such rope, when combined with an iron core by laying or twisting them around such core.

In carrying out my invention, I draw out or roll out a number of copper wires of any angular shape in contradistinction to a round or flat shape, so as to present three or more sharp edges and faces. Each one of these wires is then twisted around its own axis, and a plurality of these wires laid or twisted into a rope, *b*. A suitable number of such ropes having thus been prepared, they are spirally laid or twisted around a core, *a*, so as to entirely cover and hide the core, and so that the complete rod presents on its entire surface an infinitesimal number of broken surfaces, sharp edges, and angles, which very materially increase the capacity of the rod to attract and conduct the electric fluid.

The use of an iron core, while it increases the galvanic activity of the rod, also gives it a larger bulk at a reduced expense, the entire outer surface being copper, while the strengthening core *a* is of the cheaper iron.

A rod formed according to my improvement presents a very handsome appearance, while it is a reliable and certain lightning-conductor.

Having described my invention, I claim—

A lightning-rod consisting of a plurality of angular copper-wire ropes, constructed essentially as described, when combined with and laid around an iron core, essentially in the manner set forth.

DAVID MUNSON.

Witnesses:

THOS. H. BOWLES,

CHARLES W. TAYLOR.

ÆTHERFORCE

J. C. BRYAN.

Lightning-Rods.

No. 160,151 Patented Feb. 23, 1875.

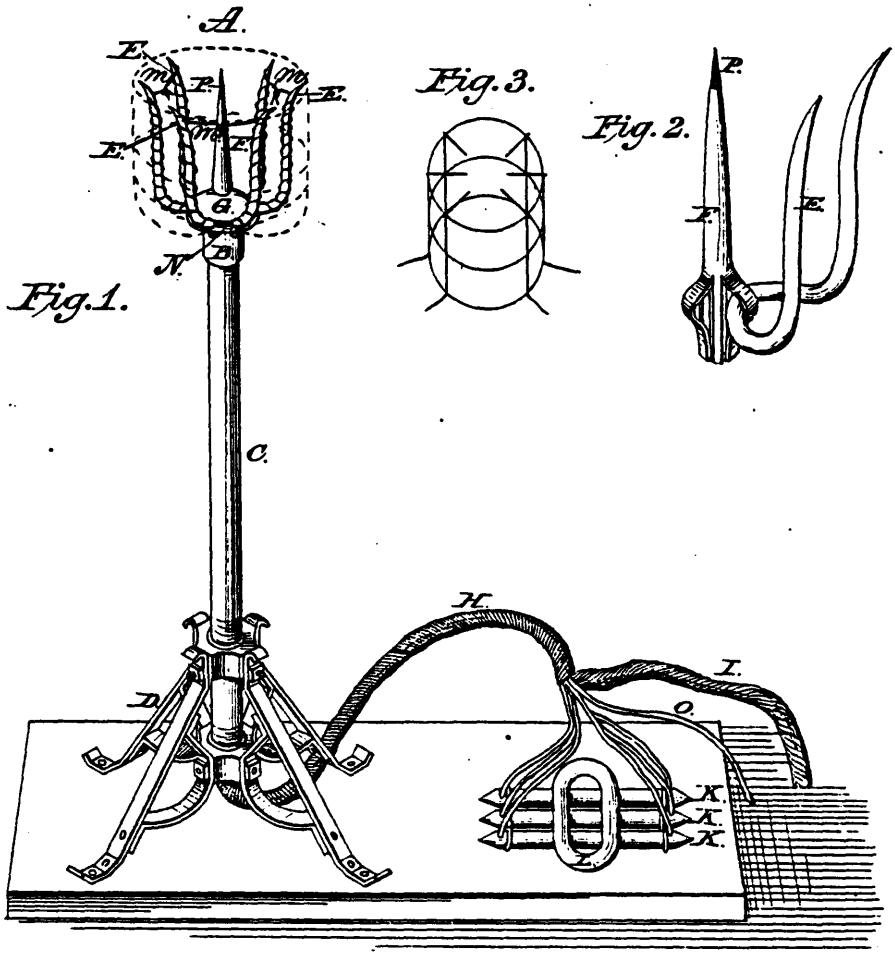


Fig. 1.

Fig. 3.

Fig. 2.

Attest:

John A. Ellis.

John P. C. Reinhart.

Inventor:

Jas. C. Bryan.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

JAMES C. BRYAN, OF PHILADELPHIA, PENNSYLVANIA.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **160,151**, dated February 23, 1875; application filed January 27, 1875.

To all whom it may concern:

Be it known that I, JAMES CHAPMAN BRYAN, of Philadelphia, State of Pennsylvania, have invented a certain Improvement in Lightning-Rods and Fixtures of the same; I do hereby declare the following to be a full and correct description of the same, reference being had to the accompanying drawings forming a part of this specification.

The object of my invention is to produce a lightning-rod capable of collecting, conveying, and discharging the heaviest charge of electricity.

My invention consists of magnetic batteries applied to the top and bottom of the rod, aiding to collect and disperse the electricity through several points in the atmosphere and earth. They are connected by a rod capable of conveying the heaviest charge of lightning. The rod being surrounded by a protector, I call this the "Magnetic Lightning-Rod."

In describing this rod I will first explain the construction of the magnetic batteries. For the top I take three nickel-plated steel magnets, E, bent, as shown in Figure 2, by and upon a machine invented and patented by me, and a central copper point, F, silver plated, and solid platinum at the tip P, and, placing them in a suitable mold, I cast around their junction a flattened ball, G, of chemically-pure zinc. The under side of this ball is formed with a cavity, the sides or flanges of which project over and down upon the socket B of the hollow standard or staff C, as shown at N, thus preventing the access of water to the interior of the staff. This I call a magnetic battery, and I find that from its construction the parts thereof will not oxidize. For the bottom I take three straight double-pointed and nickel-plated steel magnets, K K K, and, placing them in a suitable mold, unite them by casting around them a ring or circle, L, of chemically-pure zinc. This I designate the magnetic earth-battery. The rod H I make of seven large copper wires, Nos. 9 and 10 wire-gage. These may be twisted together or laid straight. Around them I wrap several small copper wires to cover the surface of the large wires, designated as protector I. I take six of the large wires of the rod H and wrap them in alternate directions around the arms or poles of the horseshoe-magnets E, one wire around each pole. I then unite the two wires passing around the limbs of each magnet, as shown at M, so that the wires act as the keeper for the magnets. The seventh or center H and the protector I pass into and attach to the copper point F. The entire rod H is then passed through the support B, which is provided with cavities for the large wires to pass through B and around G, and then through staff C. This staff is supported by a standard, D, whose construction is fully described and claimed in another application for patent made by me. At the ground end I untwist the rod and taking the central or seventh wire O and protector I pass them to one side and away from the earth magnetic battery, before described. The other six wires I wind around the poles of the earth-magnets K near the ends thereof. This earth-battery is buried several feet below the surface and in a direction coincident with magnetic poles of the earth-battery. In this arrangement the upper magnetic battery serves to collect and disperse any atmospheric current of electricity, while the earth magnetic battery performs the same office for any earth-current, thus causing and maintaining an equilibrium of electrical conditions.

As the points of rods often become encumbered with flags, streamers, kites, &c., I have devised the screen shown in Fig. 3 and dotted lines, Fig. 1, to protect the points from the same. I take iron or brass wire and form it into the shape shown over a wedge-block made for the purpose. The wires are secured together at their points of intersection in any suitable way. This screen or frame is then placed over the upper magnetic battery and fastened at the base of the zinc ball G to the large copper wires of H, and at the top to the magnets at the junction M M M of the wires.

What I claim, and desire to secure by Letters Patent, is—

1. The combination of the curved horseshoe steel magnets E, the wires wound around them and connected at M, the ball of chemically-pure zinc, having cavity N, and the connection of copper point F, substantially as and for the purpose as set forth.

2. The straight steel magnets K, in combination with the ring or circle L of chemically-pure zinc, substantially as and for the purpose set forth.

3. The combination, with the series of magnets K K K and E E E, of the rod H, constructed as described, and provided with the protector I, substantially as and for the purpose set forth.

4. The point-defender, consisting of the wire-net, constructed as set forth, and attached to the upper group of magnetic points, substantially as and for the purpose set forth.

JAMES CHAPMAN BRYAN.

Witnesses:

JOS. T. K. PLANT,

THEOPHILUS S. KIMMELL.

ÆTHERFORCE

J. C. BRYAN.

Lightning-Rod.

No. 160,154. Patented Feb. 23, 1875.

Fig. 7.

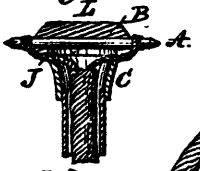


Fig. 2.

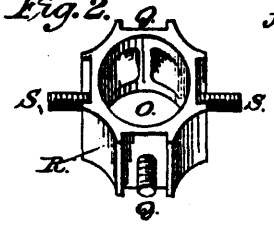


Fig. 1.

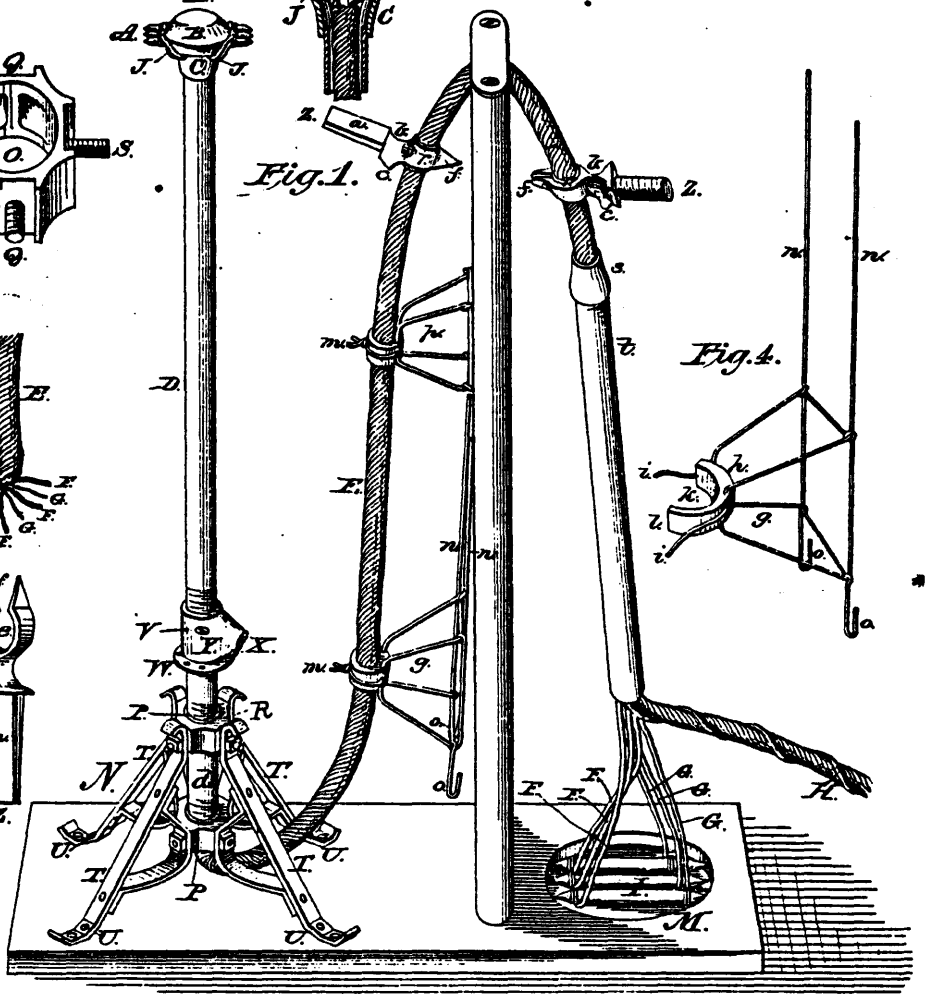


Fig. 3.

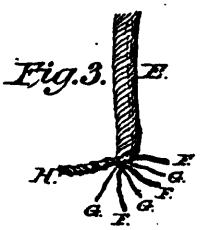
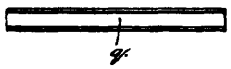


Fig. 4.

Fig. 5.

Fig. 6.



Attest:

John A. Ellis

John F. C. Reinkert

Inventor:

Jas. C. Bryan

UNITED STATES PATENT OFFICE.

JAMES CHAPMAN BRYAN, OF PHILADELPHIA, PENNSYLVANIA.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **160,154**, date February 23, 1875; application filed January 27, 1875.

To all whom it may concern:

Be it known that I, JAMES CHAPMAN BRYAN, of Philadelphia, State of Pennsylvania, have invented a new and useful Improvement in Lightning-Rods and Fixtures pertaining to the same, that I style "The Magnetic Electrical Lightning-Rod;" and I do hereby declare the following to be a full and correct description of the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, making a part of this specification, in which—

Figure 1 represents a side elevation of the magnetic electrical lightning-rod with its arrangements and devices, as hereinafter described; Fig. 2, the center metallic casting for standard, without the lead that supports the staff; Fig. 3, the rod in detail; Fig. 4, the wire roof-fastening for supporting the rod; Fig. 5, metallic fastening for supporting the rod; Fig. 6, the lead insulator surrounding the rod; Fig. 7, the point-extension over the staff for protecting the rod.

The object of my invention is to produce a lightning-rod that will attract from the atmosphere or the earth, and disperse the heaviest charge of electricity through several channels, thereby causing an equilibrium between the positive and negative powers of that element; further, to so erect and fasten a rod in position that, while firm and substantial, no stains on building, leakage, or injury to roofs may be caused.

My invention consists of those features more particularly hereinafter described and claimed.

I take three straight double-pointed nickel-plated steel magnets, A, Fig. 1, and around their centers I cast, by aid of any suitable mold, a flattish ball of chemically-pure zinc, B, which creates a galvanic action in the steel magnets A. This arrangement I call the magnetic battery, L, the magnets of the battery L being placed north and south on top of the rod, according to the magnetic poles, for the purpose of collecting and dispersing electricity. The zinc ball B has a cavity in the lower part that allows it to extend over socket C, as represented in Fig. 7, thus keeping the water from entering the hollow staff D. The rod E, Fig. 3, consists of six large insulated copper wires of different numbers, (say, Nos. 9 and 10,) F and G, arranged in alternate numbers to surround a center copper wire, H. These wires F G, F G, F G, and H may be twisted together or straight, as desired. They are surrounded or protected on the outside by small ropes, composed of small copper wires (seven of No. 25 wire-gage) twisted around F G F G F G at the angle of forty-five degrees, so as to inclose the surface, thus making the complete rod E. I use two sizes or numbers of wire for rod E, so that the different connections to the batteries used may be readily traced and followed. At the other end of the rod I plant in the earth what I call my magnetic earth-battery, M, consisting of three straight double-pointed nickel-plated steel magnets, placed north and south to be affected by the earth's magnetic currents, to attract and disperse the electricity.

In erecting, I place the magnetic battery L on staff D *d*, resting on socket C, which is part of D *d*. I pass rod E through staff D *d*, which is made of tubing; then lap the copper insulated wires F F F around the positive poles of the magnets A, to near the end of poles or points, without insulation. The same way lap G G G around the negative poles of the magnets A. In socket C, apertures being made for wires F F F and G G G to pass from staff D *d* at J J, take the other end of rod E, and connect it with the magnetic earth-battery M; lap F F F around the negative poles of the magnets I, to near the end of poles or points, without insulation, and in the same way lap G G G around the positive poles of the magnets I, to near the end of poles or points without insulation.

The large copper insulated wires F F F and G G G act as the keeper of a horseshoe-magnet, between the magnets A and I of the batteries L and M, connecting them and conveying a current of electricity through G, I, F, and A.

The large copper wire H, with the protector of rod E, passes to one side of the magnetic earth-battery M, aiding as a discharger. I designate this arrangement as the "Magnetic Electrical Lightning-Rod," as the electricity is

ÆTHERFORCE

collected and dispersed through magnetic points of batteries placed in the atmosphere, and earth current from the negative points of the atmosphere through several channels to the positive points of the magnetic battery of the earth-current; also, the negative electricity of the earth is collected by the positive points of the magnetic battery of the earth, and conveyed through several channels to the magnetic battery on top, where it is dispersed by the negative points in the atmosphere, thus causing an equilibrium. Of the standard N, in Fig. 1, that supports staff D *d*, center piece R (see Fig. 2) is made of malleable iron or brass. Its center O has cavities on the inside, in which lead P (see Fig. 1) is run, allowing staff D *d* to pass through the upper and to screw in the lower block R, which is surrounded on the inside by P, so as to hold D *d* firmly and not allow the lead P to get loose. The block R has channel Q on each of its sides, with bolts S, extending out from center of Q, each holding a leg, T, which is composed of two pieces of wrought-iron or brass riveted together, with screw-holes in the lower curve at U for screws to enter to hold it in its position on the building, and with a hole in that portion that passes through channel Q of block R, fitting the bolt and secured thereto by nuts.

By the above arrangements I procure a firm pliable standard that can be taken apart for transportation.

The spire-protector V consists of malleable iron or brass casting, with a hole through the center, in which threads are cut in, so that the tubing D may be screwed therein from above and tubing *d* from below. The lower part of V is made several inches wider than the top, and into a flat surface, as at W. Through the top of a spire or pinnacle a hole is bored, the lower part of staff *d* passing down into the hole, while W rests on top, being held firmly in its position by screws. Through V there is a side hole, X, inclining upward above W for the rod E to pass through up the staff D. The upper part of X extends over so no water can enter staff D *d*. The screw Y holds V and L together, so that, if vanes be erected on staff D *d*, indexes will not get out of position. By these means I convey the rod E outside of the building, and no water can enter the wood around the staff, while the cardinal-points indexes are kept in their true position. Of the fastening Z, composed of malleable iron or brass, *a* is the section that is screwed or driven into the building. *b* is an inclined shoulder between *a* and rod E. *c* is a dip or extension on the lower part of Z, below *b*, to carry the water from the building, so that no stains be caused on the same. *e* is a hollow cavity with two extensions or tapering points, *f*, as shown in Fig. 5, and surrounded on the inside by an insulator, Fig. 6. When the rod E is placed in cavity *e*, and surrounded by insulator Fig. 6, the two tapering points of *f* are pressed together to hold rod E in position, and *f* answers for a point to collect and discharge electricity. The shingle or slate fastening *g* is composed of iron or brass wires, bent or formed over a mold, so that they will be three and a half inches apart at the base, and cross each other at a height of three inches, and in a three-quarter-of-an-inch square, as at *h*. *i* represents a wire that crosses at *h*, for tying, as shown in Fig. 4. The top *h*, with wire *i*, is inclosed in lead by a mold made for the purpose, with a lead or hollow cavity, *k*, for the rod E to lie in, and with an extension of lead, *l*, to lap over rod E when the ends of *i* are closed together, as at *m*. At the base extend two wires, *n n*, to be placed under the layer of shingles or slates above where it is placed on the roof, and *o o* designate two bent wires from the opposite side *n n*, to be placed under the shingles or slates it sits upon, all being firmly joined together. By removing the wires *n n* and *o o* I have a tin or gravel roof fastening, as at *p*, Fig. 1. The application of these fastenings does not injure the roof, and the rod E has a chance to contract and expand, winter and summer, and no rubbish collects on the roof. Fig. 6 represents a piece of flat lead used as an insulator for Z, with a groove through the center, on one side, as at *q*, to fit cavity *e*, Fig. 5, which leaves a shoulder, *r*, Fig. 1, on each side of Z, when the tapering points *f* are closed. It is used on account of its pliability, keeping the water from entering between the rod E and fastening Z, and also because it is considered the best non-conductor of all the metals.

It is customary to pass the rod through a piece of tubing before it enters the earth, then staple the tubing firmly to the building, so that the rod cannot be disturbed. In winter, the water enters the tubing, freezes, and bursts the tubing. To prevent this from occurring I have made a mold to run lead, and make a socket, *s*, Fig. 1, to fit around rod E and to extend down on the outside of tubing *t*, pressing the lead tight around rod E, so no water can enter the tubing *t*, and thus protecting rod E from being disturbed.

What I claim as my invention is—

1. The combination, with the upper terminal of a lightning-rod, of the series of steel magnets A and the ball of zinc partially inclosing the magnets and extending over socket C, substantially as herein set forth.

2. The rod composed of the series of insulated wires F, F, F, G, G, G, and H, wound as described, and wrapped with a protector, substantially as herein set forth.

3. The combination, with a lightning-rod composed of the series of wires, as described, of the terminal magnets, batteries L and M, each single magnet of either battery being connected to one magnet of the other battery by insulated wires connecting their opposite poles, substantially as and for the purpose set forth.

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4. The combination, with a lightning-rod, of the series of magnets placed at the lower end thereof, and forming a magnetic earth-battery, substantially as and for the purpose herein set forth.

5. The supporting-standard N, consisting of the central portion O and lead P, provided with cavities Q, bolts S, and grooves, constructed as shown, the parts being arranged and combined substantially as and for the purpose herein set forth.

6. The spire-protector, consisting of the tube provided with flange W, orifice X, and fastening-screw Y, substantially as and for the purpose herein set forth.

7. The inclined shoulder *b*, dip *c*, tapering points *f* of the metallic fastening Z, as herein set forth.

8. The roof-fastenings consisting of the frame and tie wire *i*, secured together by the lead fillet or band *h l*, cast thereon, and extensions *n o*, substantially as and for the purpose herein set forth.

9. The insulating strip of lead having a groove along its center to fit within the arms *f* of support Z, and the side flanges for extension over the arms *f*, substantially as and for the purpose herein set forth.

10. The combination, with the rod and the protecting-tube *t*, of the lead socket or protector *s*, extending over the top of the tube and grasping the rod, substantially as and for the purpose specified.

JAMES CHAPMAN BRYAN.

Witnesses:
JOS. T. K. PLANT,
THEOPHILUS S. KIMMELL.

ÆTHERFORCE

J. A. KLECKNER.

Lightning-Rod.

No. 162,828. Patented May 4, 1875.

Fig. 1.

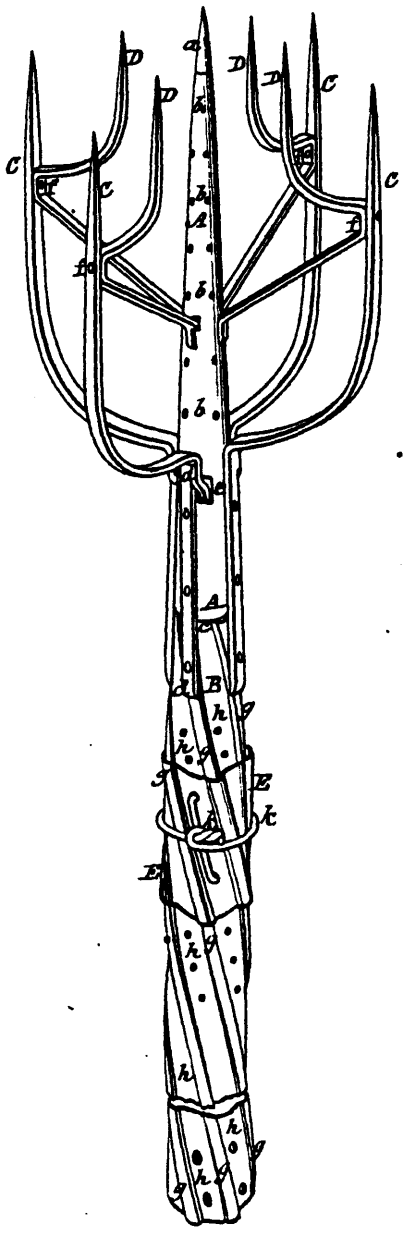

Fig. 2.

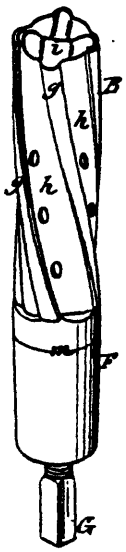

Fig. 3.

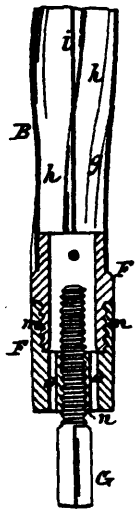

Fig. 4.

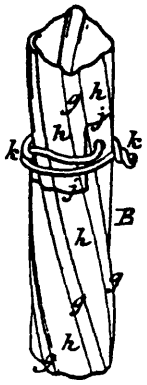

Fig. 5.

Witnesses.

D. P. Cowl

Edmund Mason

Inventor.

John A. Kleckner.

By atty A. B. Stoughton.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

JOHN A. KLECKNER, OF CANTON, OHIO, ASSIGNOR TO HIMSELF AND HENRY F. SHOLTY, OF SAME PLACE.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **162,828**, dated May 4, 1875; application filed January 26, 1874.

To all whom it may concern:

Be it known that I, JOHN A. KLECKNER, of Canton, in the county of Stark and State of Ohio, have invented certain new and useful Improvements in Lightning-Rods and their Attachments; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings making a part of this specification, in which—

Figure 1 represents, in perspective, the points and upper portion of the rod, together with a portion of the body or conductor, and a means of uniting the sections thereof. Figs. 2, 3, and 4 represent details of the construction of the rod, which will be more particularly referred to hereafter. Fig. 5 represents an end view of the coupling device shown at Figs. 2 and 3.

My invention relates to a lightning-rod made tubular or hollow, and ribbed or corrugated to increase the extent of conducting-surface, both inside and outside of the rod, and braced inside for a similar purpose, as also to give increased strength, and furnished with a series of points so made as to receive and conduct the fluid partially on the exterior and partially on the interior conducting-surfaces, and with openings or holes, through which the fluid may pass from the exterior to the interior of the rod, and vice versa, all of which will be more particularly described in connection with the drawings.

The main central point A is made conical and hollow, and tipped with platina *a*, or other suitable metal. This point has through it a series of holes, *b*, for allowing the fluid to divide and pass off partially on the interior and partially on the exterior surfaces thereof. The point A is connected to the main rod B at *c* by rivets or otherwise. Around the central point A are arranged a series of brace-points, C C, &c. The tangs *d* of these brace-points C are split or divided, one branch extending down outside of the main point A, crossing the joint *c*, and riveted to both the point A and the main rod B. The other branch of the tang passes through an opening, *e*, in the main point into the interior thereof, so as to divide the fluid over the interior as well as the exterior conducting-surfaces. The brace-points D, after being united, as at *f*, to the outer series C, then extend to and into the main point A, their tangs being divided, as and for the purpose above mentioned, in relation to those *d*. Openings are made through the main rod at various points or distances throughout its length, so that the fluid may equalize itself by passing from the exterior to the interior, or vice versa, as the case may be. The ground end of the rod is also furnished with holes or openings, so that the fluid may pass therethrough from the interior of the hollow rod into the earth. The main rod A is best when made of copper, and to make it light, strong, and inexpensive the copper may be thin, but formed of a series of spiral raised ribs, *g*, with plain, or slightly-arched or corrugated, lands *h* between them, and across the interior of the so made hollow rod is a corrugated wall or partition, *i*, which adds not only to the extent of interior conducting-surface, but materially strengthens the rod itself. The main rod B, being made of sheet metal, ribbed and corrugated as described, will be in sections, which must be united when the rod is to be put up. To make a convenient and ready splice, I shoulder and recess the adjacent ends of the sections, as at *j*, Fig. 4, forming, as it were, alternating tongues and grooves; and these being matched and slipped one into the other, a wire, *k*, is passed through the lapped ends, and brought around the exterior and fastened, as seen in Fig. 4. Such a splice will answer in most cases; but if the rod be heavy and much exposed, then a sleeve, E, as in Fig. 1, may be first passed over this tongue and groove or lapped joint *j*, and the wire *k* run through around the joint and sleeve, which will greatly strengthen the splice. If it be desirable to connect the point and portion of this special rod to any other kind of a lightning rod or conductor, a coupling-pin, as at F, Figs. 2, 3, 5 may be used, wherein B represents my form of rod, and G represents another form of rod to be united thereto. The coupling-piece F is made in two parts, which screw together, as at *m*, and it is, moreover, hollow, for a purpose to be hereinafter mentioned. The rod B is set over a shoulder on

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the upper end of the coupling, and riveted to it. In the lower end of the coupling is a nut, *n*, with openings *o* around it, which connect with the open space through the coupling, so that a hollow rod, B, may be connected with a solid one, G, and both the exterior and interior conducting-surfaces of the hollow rod lead onto the exterior of the solid rod. To unite the two kinds of rods, the coupling F and its connected section and points is screwed onto a screw-shank on the rod G, as seen at Fig. 3.

Having thus fully described my invention, what I claim is—

1. In combination with a hollow, ribbed, or corrugated main rod, the hollow conical main point A, when both the rod and point are pierced to admit the passage of the fluid into the interior of the point and rod, as and for the purpose described.

2. In combination with the hollow and pierced point and rod, the brace-points, with branched tangs, so as to conduct the fluid both onto and into the hollow point or rod, or both, substantially as described.

3. The tongued and grooved joint and wired splice *j k*, with or without the sleeve E, as and for the purpose described.

4. In combination with the hollow, ribbed, corrugated, and pierced main rod B, the coupling-piece F, for the purpose of joining said rod B to a solid rod of any kind, as described and represented.

JOHN A. KLECKNER.

Witnesses:
S. SLANKER,
W. W. CLARK.

ÆTHERFORCE

C. STEARNS.

Lightning Rod.

No. 65,775. Patented June 11, 1867.

Fig. 2

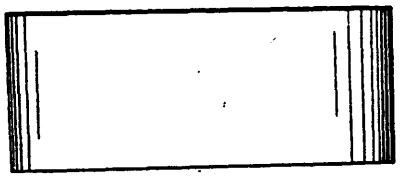
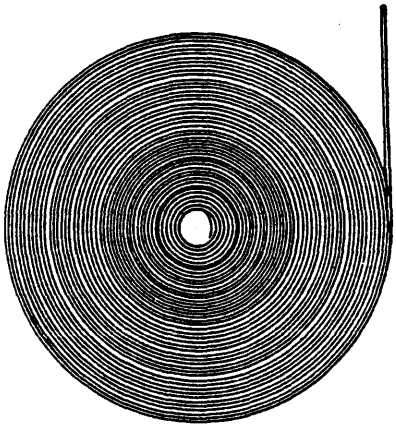


Fig. 4

Fig. 3

Fig. 1



Witnesses:

P. C. Howle

Alex. McCormick

Inventor:

Chas. Stearns

By atty E. N. Scott

United States Patent Office.

CHARLES STEARNS, OF LOWELL, MASSACHUSETTS, ASSIGNOR TO JACOB A. KISSELL, OF CHICAGO, ILLINOIS, WHO ASSIGNS HALF OF HIS RIGHT TO NATHAN BLICKENSDERFER, OF ERIE COUNTY, PENNSYLVANIA.

Letters Patent No. 65,775, *dated June* 11, 1867.

IMPROVEMENT IN LIGHTNING-RODS.

The Schedule referred to in these Letters Patent and making part of the same.

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Be it known that I, CHARLES STEARNS, of Lowell, in the county of Middlesex, and Commonwealth of Massachusetts, have invented a new and useful Jointless or Solidly Continuous Sheet-Metal Lightning-Rod; and I hereby declare that the following specification, in connection with the accompanying drawings, constitutes a lucid, clear, and exact description of the same. In referring to said drawings—

Figure 1 denotes a side view of the coil of sheet metal ready for being formed.

Figure 2, an edge view of the same.

Figure 3, an exterior view of my rod after being shaped.

Figure 4, an end view of it.

Invention: The nature of my invention consists in a solidly continuous sheet-metal or copper lightning-rod, having great inherent strength, and which is corrugated and twisted, or otherwise formed or shaped, to readily catch the electric fluid by its varying and projecting edges, and to embody sufficient stability and strength for erection and permanent support, and at the same time be susceptible of being bent to conform to the inequalities and shapes of the structure without impairing the appearance, strength, or effect of the rod, and at the same time not requiring a single joint in it for the whole structure.

Construction: To enable others skilled in the art to which my invention appertains to construct and carry out the same, I will describe it as follows:

I prefer sheet copper to other metal, by reason of its cheapness, great ductility, and density, and its great susceptibility of readily receiving and safely conveying away large volumes of the electric fluid or current. The object attained by the solid continuity of the rod is a perfect conductor, by having no breaks or joints in which the electricity will be liable to jump in traversing it, and also in its great strength and convenience of erection. The shape must be given the rod at the place of erection, as it cannot be transported after being shaped. The sheet copper is first rolled of great length, and of the desired thickness and width, and coiled into rolls, seen at figs. 1 and 2 of the drawing, which are easy to transport to any place for erecting my rod, as also the machine which I have invented and now use for corrugating and twisting the rod, which consists of corrugating and twisting rollers so combined that by entering the outer end of the coil of strip copper and turning a crank, the strip metal is passed through and uniformly corrugated and twisted, as seen at figs. 3 and 4 of the drawing. When a sufficient length of it has been shaped, it is cut off with shears, and is then ready for erection on the structure in one continuous piece from end to end; and may be secured thereto by any good insulators, the top, of course, projecting above the highest point of the building, and the lower end reaching to dampness in the earth below the building. By giving the within-described shape to the rod, it is impossible for the lightning to strike the rod without coming directly in contact with the edges of the sheet metal, which are doubly continuous the entire length of the rod.

Various curves or shapes may be given the rod, but the corrugated and twisted shape I deem preferable to any other.

The cheapness of my rod and of its application is obvious, from avoiding all joints and splices and contrivances for that purpose in the old rods. But the most prominent feature is in the great conducting power of the rod, and the additional safety thereby guaranteed to life and property, and without additional expense.

What I claim as my invention, and desire to secure by Letters Patent, is—

A lightning-rod or conductor, consisting of a solidly continuous strip of sheet metal, substantially as described.

CHAS. STEARNS.

Witnesses:

E. W. SCOTT,

M. A. SCOTT.

ÆTHERFORCE

H. W. SPANG.

LIGHTNING-ROD.

No. 6,835. Reissued Jan. 4, 1876.

Fig. 1.

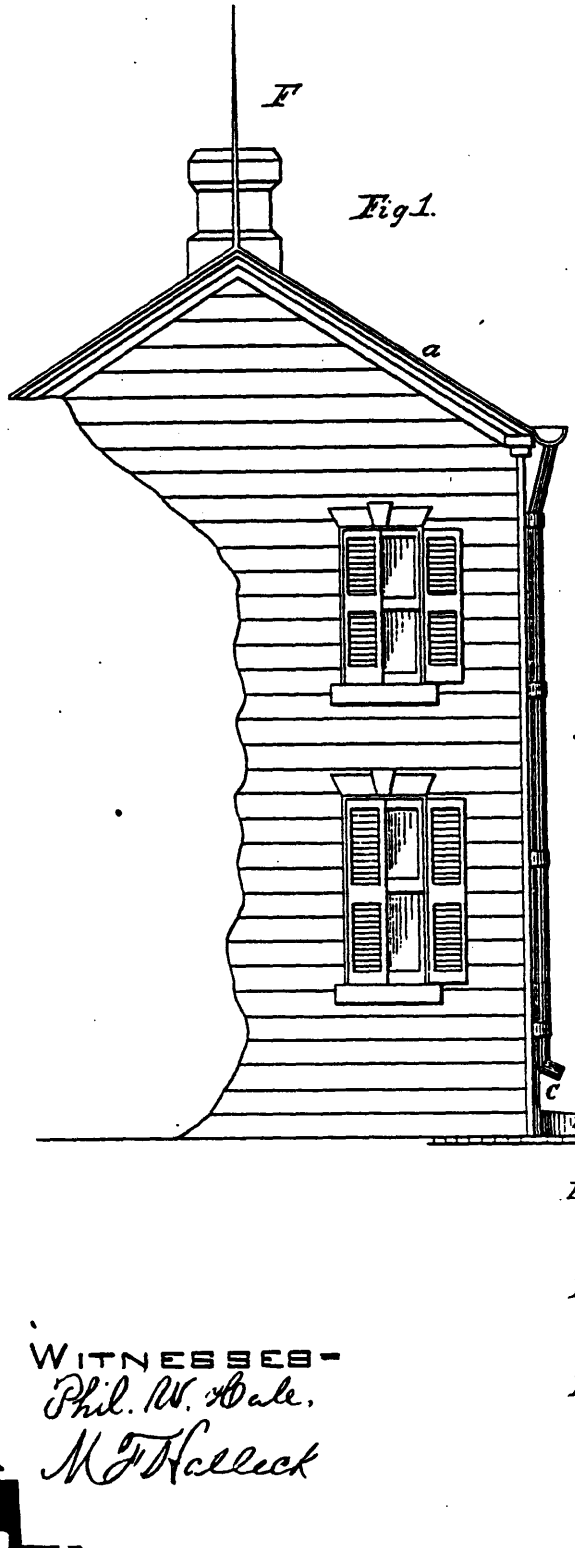


Fig. 2.

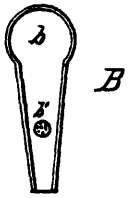
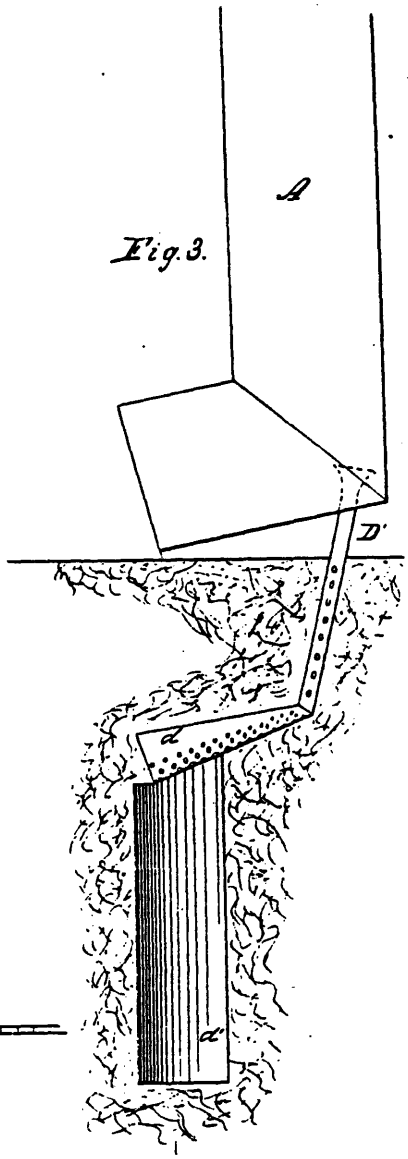


Fig. 3.



WITNESSES—
Phil. W. Hale.
M. F. Halleck

INVENTOR—
Henry W. Spang,
Wm. Beale Hale.
Attorney.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

HENRY W. SPANG, OF READING, PENNSYLVANIA.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. 167,415, dated September 7, 1875; reissue No. 6,835, dated January 4, 1876; application filed December 14, 1875.

To all whom it may concern:

Be it known that I, HENRY W. SPANG, of Reading, in the county of Berks and State of Pennsylvania, have invented certain new and useful Improvements in Lightning-Conductors; and I do hereby declare that the following is a full, clear, and exact description thereof, that will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention consists in connecting an ordinary metallic rain-pipe of a house or other structure with a metallic roof or other lightning attractor or conductor at its top, and with a perforated metallic pipe placed in the earth near its bottom or foot, and a suitable distance from the foundation-walls of the house, and arranged so as to form a perfect line of electrical conductors, and keep the earth surrounding the said perforated pipe, and any other terminal metallic conductor connected therewith, moist by means of rain or waste water, and thereby secure a good earth-connection therefor, and also afford means by which a portion of the attracted electricity will be diffused, during a thunder-storm, over the flowing rain-water, and into the moist surface of the earth; the said metallic rain-pipe being connected with the perforated pipe by means of a metallic drain or gutter, pipe, rod, or other suitable conductor, or directly therewith. It also consists in an improved earth-terminal for lightning conductors or rods, consisting of a metallic pipe with perforations or openings along its entire length or sides, so that the rain or waste water which enters the pipe will not only flow into the earth at the bottom, but also into the earth along the whole length of the pipe, thereby causing a larger amount of earth to be readily saturated with water, and enabling lightning or atmospheric electricity to be more readily diffused than by any other method, device, or devices heretofore employed for moistening the earth surrounding the terminal conductor and diffusing lightning.

The details of construction involved in my invention, and the operation thereof, will be fully explained in the following specification, with reference to the accompanying drawings, in which—

Figure 1 is a view in elevation of my invention. Fig. 2 is a plan view of a metallic drain or gutter. Fig. 3 shows a modification of my invention.

A is an ordinary metallic rain-pipe, connected with, and leading from, the metallic roof *a* of a house at the gutter or trough *a'* thereof. B is a metallic drain or gutter, the basin *b* of which receives the rain or waste water flowing through and from pipe A. This drain or gutter is connected to pipe A by a metallic rod, C, pipe, or other suitable metallic conductor, and near the mouth of the gutter, and in the bottom thereof, is an aperture, *b'*, at which a metallic pipe, D, having an opening at its top and bottom, and any suitable number of openings or perforations, E, of any desired form or size, along its entire length or sides, is connected to the drain or gutter B, and extends downward into the earth. The aperture *b'* in the bottom of the gutter B can be covered by a perforated disk in summer, said perforated disk allowing the passage of water into pipe D, but preventing the passage of trash, by which the pipe might become clogged. In the winter the perforated disk may be replaced by a solid one, so as to prevent the water entering pipe D and freezing, as at that season the earth is usually sufficiently moist, and there is seldom any thunder and lightning. When the house has a metallic roof, as shown at *a* in the drawing, and pipe A is connected therewith, an attracting-rod, F, which extends above the top of the chimney or other elevated projection of the house, should be erected directly upon the roof, and be metallically connected therewith; but in case the house has a wooden, slate, or other roof of poor conducting material, the lightning attractor or conductor F, which should also extend along the ridge of said roof in every direction, and along the edge of said roof at each gable, must be connected with rain-pipe A, or with the metallic eave trough or gutter, to which said pipe A is connected.

The drain or gutter B, or the pipe which may be used for conveying the water from

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rain-pipe A into the perforated pipe D, may be of any desired length, and may, if desired, extend into the street-gutter, or into a sewer, and the perforated pipe D may be extended from any portion of the said drain or gutter, or drain-pipe.

The perforated pipe D can be connected with rain-pipe A by means of a solid rod or bar placed on the top of the earth, or beneath the surface thereof, instead of by a gutter or pipe, as hereinbefore described, and may also be placed and arranged so that the waste-water from a pump or hydrant, or water from a gutter or stream, will also flow into the said perforated pipe D, and keep the earth about said pipe well moistened during the summer.

The pipe D can be round, square, triangular, or of any desired form, and may also have any number of perforated branches; also, an enlargement at its bottom or top, so as to hold a large quantity of water during a thunder-storm; and it can also have any other metallic terminal conductors connected therewith.

It is, however, preferable to use a straight pipe without branches, so that it can be driven downward into the earth, and the earth inside thereof be afterward taken out by means of a small auger or shovel, or be well packed in a hole made by a rod with a sharp point driven into the earth, or a hole made by an earth auger or excavator.

Instead of employing a solid iron pipe, D, round, square, or of any other suitable form, perforated with openings or holes, several curved or flat pieces or bars of iron can be used, and be fitted and held together at the top and bottom by means of metal hoops, or other suitable fastenings, so that there will be a suitable space or opening between each pair of said pieces or bars, which will allow the water to pass through and moisten the earth surrounding and beneath them, and thereby answer the same purpose as a solid iron perforated pipe, and also be convenient for causing a good contact to be made with the earth, by spreading the said pieces and pressing them tightly against the sides of a hole made by a driving-rod, an earth-auger, or excavator.

In the modification shown in Fig. 3 the perforated pipe D′ connects above ground directly with the metallic rain-pipe A, which is supposed to be in metallic connection with a lightning attractor or conductor at its top, and it has a perforated funnel or enlargement, *d*, connected therewith by an elbow-joint at the foot thereof, so as to hold a large quantity of water, and a terminal metallic plate, *d′*, is connected to and extends vertically downward from the perforated funnel or enlargement *d*, as shown. In this arrangement the perforated pipe D′ is supplied with water directly from rain-pipe A, and the said perforated pipe is near the foundation-wall of the house. I prefer, however, to have the perforated pipe placed at least six feet from the foundation-walls of the house, so as to prevent them from becoming thoroughly saturated with water. It is also advisable to make use of a gutter or drain, B, or have the upper portion of perforated pipe D or the connecting conductor placed so as to be in contact with the flowing rain-water during a thunder-storm, so that a portion of the attracted lightning will be diffused through the said flowing rain-water over the moist surface of the earth.

It is well known that in order to diffuse lightning readily into the earth and secure the proper action of lightning-conductors, it is necessary that the said conductors must terminate in, or at least come in contact with, a large and well-moist portion of the earth. Dry earth is a poor conductor, into which the atmospheric electricity does not readily flow from the terminal conductor of a metallic rod, pipe, or other lightning-conductor erected upon a house, and when said conductor does not have a suitable reservoir of well-moist earth into which to quickly and readily discharge its attracted electricity it becomes worthless as a protection, as the electricity is then apt to leave the conductor, pass into the building, and damage or destroy it, and endanger the inmates. The object, therefore, of employing the perforated pipe D and extending it downward into the earth is in order that a portion of the rain or waste water may flow into the pipe D and moisten the earth surrounding and beneath said pipe, and thereby provide a suitable reservoir of moist earth, and particularly during a thunder-storm, for the diffusion of lightning into the earth. I carry the pipe D to a distance below the surface of the earth where there is approximately permanent moisture; but as the depth to which the heat of the sun dries the earth varies during the summer, I aim to have my pipe or terminal conductor so placed that, if not actually within the line of permanent moisture, communication therewith will be very soon established after the commencement of a thunder-storm, by means of the rain-water flowing through the lower opening and perforations of pipe D.

Water is a conductor of electricity, and during a thunder-storm the greater portion of rain-water flowing from rain-pipe A passes over the drain or gutter B, or the top of perforated pipe D or connecting conductor, and spreads over the surface of the earth, or a brick or stone gutter or pavement, and reaches the earth through the interstices of the pavement, or flows into a running gutter or sewer, and the said rain-water assists in diffusing the attracted electricity from said drain or gutter B, or pipe D, or connecting conductor, over the moist surface of the earth, along the gutters, pavements, sewers, &c.

The gas-pipes in a building, or any other metallic conductor, may be used as part of the lightning-conductors, in connection with perforated pipe D, and care should be taken that a good electrical connection is made between the joints of the gas-pipes by soldering or brazing them together, or by an additional con-

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ductor, as the red lead used at the joints of such pipes is a poor conductor of electricity; and the meter must also be shunted by means of a copper sheet or wire, or other good conductor having greater conductivity than the material of the meter and the lead joints thereof, so as to prevent the meter from being damaged and the gas set on fire by the melting of the lead joints.

The pipe D, with perforations or openings E, as hereinbefore described, constitutes a much better medium for saturating the earth with water than an ordinary pipe, with the usual openings at its opposite ends, or any of the devices heretofore employed for that purpose, for the reason that the said pipe D not only saturates the earth at the bottom of the pipe, but also saturates the earth along its entire length, which is not accomplished by the ordinary pipe, or any other devices heretofore used. The said pipe D will more readily diffuse lightning and make a better earth-connection from the fact that a large amount of well-moist earth offers less resistance to the passage of electricity than a small amount of moist earth.

Having now fully described the construction and operation of my invention, I claim—

1. The combination of metallic rain-pipe A with perforated metallic pipe D, said pipes being electrically connected, as described, and forming a lightning-conductor, substantially as set forth.

2. Metallic pipe D, having perforations or openings E, as described, and for the purpose set forth.

In testimony that I claim the foregoing I have hereunto set my hand this 10th day of December, 1875.

HENRY W. SPANG.

Witnesses:

DANL. SPANG,

J. WARREN TRYON.

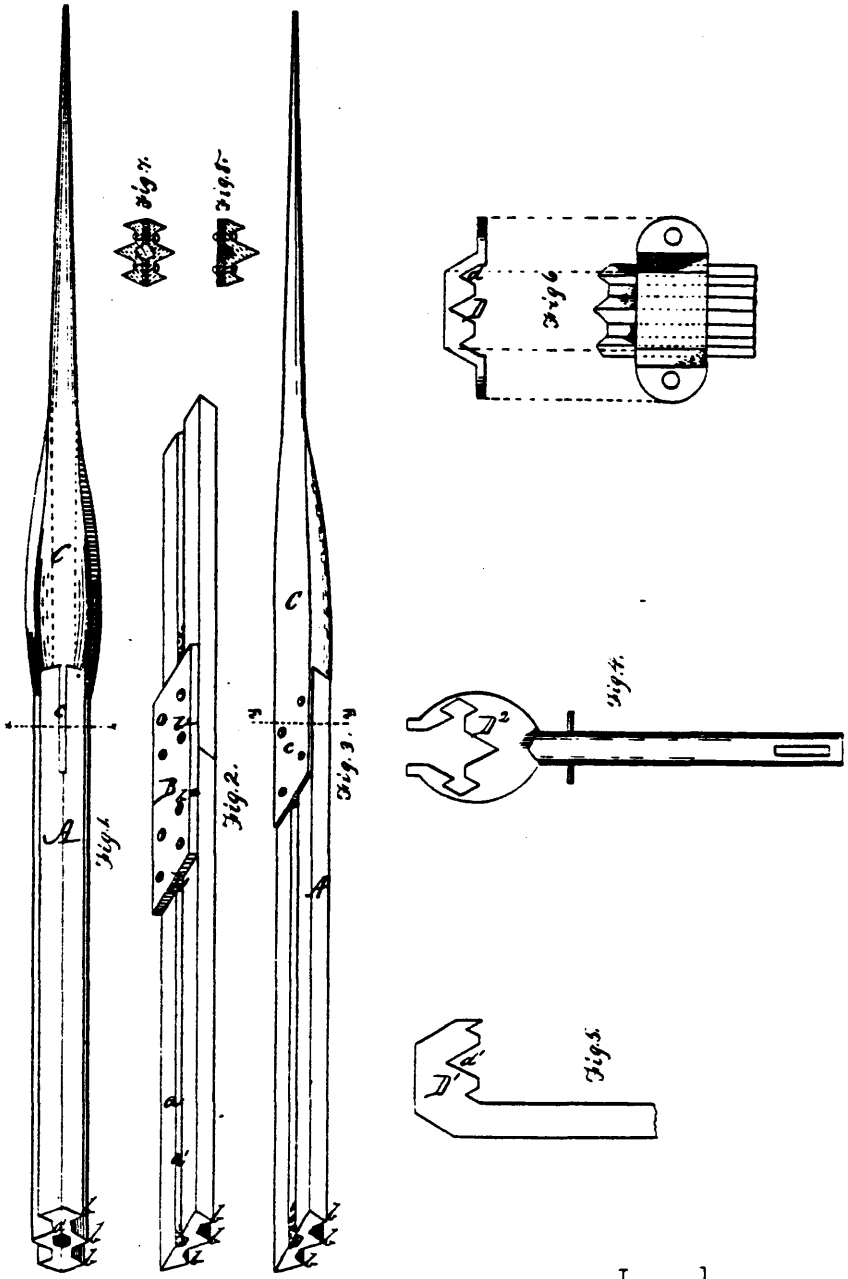
ÆTHERFORCE

2 Sheets—Sheet 1.

J. J. COLE.

LIGHTNING-RODS.

No. 185,430. Patented Dec. 19, 1876.



Witnesses.

James L. Kay

R. Williamson.

Inventor

John J. Cole

by Bakewell & Kerr

Attys.

AETHERFORCE

2 Sheets—Sheet 2.

J. J. COLE.

LIGHTNING-RODS.

No. 185,430. Patented Dec. 19, 1876.

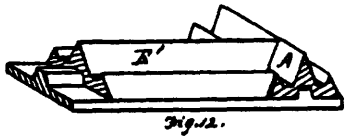


Fig. 12.

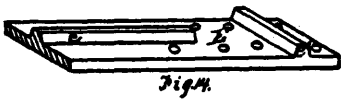


Fig. 14.

Fig. 13.

Fig. 15.

Fig. 11.

Fig. 18.

Fig. 19.

Fig. 10.

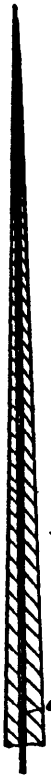
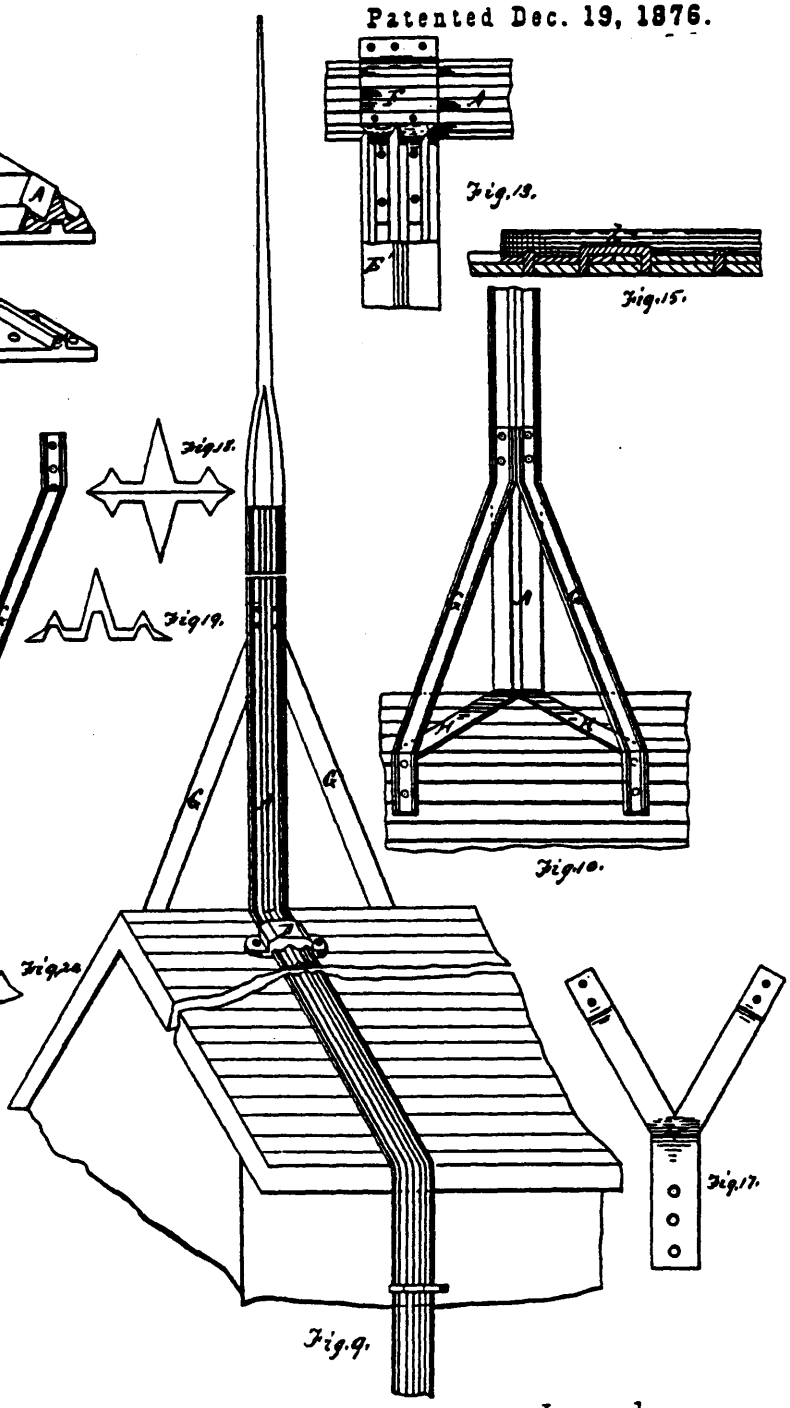


Fig. 16.

Fig. 20.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UNITED STATES PATENT OFFICE.

JOHN J. COLE, OF ST. LOUIS, MISSOURI.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **185,430**, dated December 19, 1876; application filed March 23, 1876.

To all whom it may concern:

Be it known that I, JOHN J. COLE, of St. Louis, in the county of St. Louis and State of Missouri, have invented a new and useful Improvement in Lightning-Rods; and I do hereby declare the following to be a full, clear, and exact description thereof, reference being had to the accompanying drawings, forming a part of this specification, in which—

Figures 1 and 3 are views of rods and points embodying my invention. Fig. 2 shows the manner of jointing; Figs. 4, 5, and 6, attachments or devices for attaching the rod to a building. Fig. 7 is a section on the line *x x* of Fig. 1. Fig. 8 is a section on the line *y y* of Fig. 3. Figs. 9, 10, and 11 represent that portion of my rod which is elevated above the building, as supported by the standard-legs attached thereto, with the switch between the same. Figs. 12, 13, and 14 represent my double connectors, or T-splice-plate devices for connecting two or more rods together, or for branch rods with the main line. Fig. 15 shows staple-rivet for connecting joints of rod. Fig. 16 is a section of a point, showing platinum wire. Fig. 17 is a detached view of the switch used between the standards. Figs. 18, 19, and 20 illustrate modifications based on the plain-back and ribbed-face rods.

Like letters refer to like parts wherever they occur.

My invention relates to the construction of lightning-rods and their attachments; and consists, first, in forming the rod with one flat or plain surface, having a splice-groove and a longitudinally ribbed or guttered face, whereby the rod may be employed in single line, and will apply itself to the building, or may be used in double line, back to back, if preferred; second, in forming the point with a platinum wire of sufficient length to prevent the destruction of the point by a discharge of lightning, the body of the point being cast upon the wire at the time the point is formed; third, in supporting the upright portion of the rod above the building by braces connected directly to the main rod and building, in which the main rod may form one leg of the brace, if desired; fourth, in connecting the brace and ground rods by a metallic connection or switch, forming a circuit to facilitate the discharge of that portion of the electricity with which the braces may become charged; fifth, and finally, in details of construction pertaining to the rod and its attachments, hereinafter more specifically set forth.

Upon investigation I have discovered that it is as necessary to attach a properly-constructed point to the lower end of the lightning-rod, which goes into the ground, as to the upper end, which extends into the air, for the following reasons: first, to discharge the positive electricity which is received by the rod from the cloud, and, second, to receive upon the rod the negative electricity, which, under certain circumstances, is discharged by the rod from the earth into the air. It is a well-established fact that a fine point is the best discharger of electricity as well as the best receiver of it; therefore, every lightning-rod should be provided with a properly-constructed point at each end. But scientists, in their treatises upon the subject, have not described such a rod, and manufacturers of lightning-rods, in the practical application of the science, have, in no instance, furnished their rods with a ground point.

While great stress has been laid upon the necessity of a properly-constructed point for the top of the rod, no attention has been paid to the furnishing of a point to receive and discharge electricity at the earth. Now, I meet this requirement by attaching to the lower end of my lightning-rod a platinum-tipped point, constructed substantially as the point above described in second statement of invention, with such changes as render it more suitable for a ground point, and leaving off the ornamental finish, which would be useless under ground.

I will now proceed to describe my invention, so that others skilled in the art to which it appertains may apply the same.

In the drawings, A indicates the rod, which may be made solid, or of sheet metal, or of any suitable metal, preferably iron and solid, formed with a flat back, *a*, which is generally grooved, as at *a'*. Upon the reverse or face of the rod are a series of longitudinal ribs or flanges, *b b b*, the middle rib, when three are used, being preferably larger than the edge ribs. This form of rod gives an increased

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conducting-surface with the requisite strength and lightness; and when the rod is rendered negative, the positive current, by the mutual repulsion of its particles, will travel on the two outer flanges, leaving the central flange either as neutral ground or for the ascent of the negative current; it is therefore essential that the flanges or ribs shall be of unequal height. When the groove *a'* is omitted the joint between the sections may, in a single line of rod, be made by riveting a flat plate to the sections by a thimble, or in any of the well-known ways; but as I preferably groove the flat face of the rod, I have provided a special connecting-plate, B, which corresponds in width with the rod, and has upon one face a longitudinal rib, b^1, which corresponds to the groove *a'* of the rod. The ends of the sections, being adjusted, (see Fig. 2,) are secured by staple-rivets b^2, Fig. 15, which lie within the gutters formed by the ribs *b b*, thus lapping or crossing the joint, insuring contact, and increasing the strength of the joint. C indicates the point, which may be used either as an initial or terminal point, and which may vary in shape, (see Figs. 1 and 3,) according as it is used with a single or double line of rod, but, in either case, constructed on the same principle. It is preferably grooved at its lower portion to correspond with the ribbed rod, and is provided with a flange, *c*, by means of which it may be riveted to the single or between the double line of rod of the superior section. The points C are usually of copper, and are provided with a central wire, *c'*, Fig. 16, of platinum, which is inserted at the time of forming or casting the point, so that, should the point be melted at any time, it does not become useless, as is the case where it is simply tipped in the ordinary manner, but may be removed, sharpened, and replaced at little expense and with slight labor. Platinum-tipped points, as ordinarily constructed, in which the wire is secured in the tip by soldering, the passage of the electricity destroys the solder, and the wire becomes loose in its socket, and is liable to fall out, and, having no proper metallic contact with the body of the point, is comparatively useless if it remains in. This difficulty I overcome in my point by casting the body of the point about the platinum tip, thus making a union between the two that is not destroyed by the passage of the electricity, and which serves to retain the wire firmly in place, however often the point may be subjected to a discharge of lightning. Where the wire extends the whole length of the point, it will serve to re-enforce the conducting power of the point, and, by facilitating the transmission of the charge to the main rod, (the wire itself being capable also of sustaining high heat,) will materially retard or even prevent the melting of a point. When the sole object is to permit of the resharpening the point, the wire need not be extended for more than an inch and a half or two inches, as more would only a[illegible] expense of the point, and, so far as is at present known, the heaviest discharge has seldom melted more than from three-fourths to one inch of a point, and this is not likely to occur if the contact is perfect and a terminal point (as hereinafter specified) is employed.

D D^1 D^2, Figs. 4, 5, and 6, are a series of devices devised by me, and adapted for securing the rod to buildings. Of these D D^1 are especially intended for the single rod, and are grooved, as at *d d'*, to fit the ribbed face, the flat face of the rod resting against the building. D^2 may be employed when the rod is used double, (see Fig. 1,) and its shape is such that it may be sprung open to introduce the rod, after which it may be bent together to clamp the rod securely. E, Fig. 14, is a splice-plate or connector for making connections between two or more rods, or connecting branch rods with the main line. This plate is generally of equal width with the rod, and has a longitudinal rib, *e*, which fits the groove *a'* of the branch, and a transverse rib, *e'*, which fits groove *a'* of the ground rod. In making the connection between the branch and ground rods the branch rod E', Fig. 12, is preferably beveled, so as to fit snugly against the ground rod A. The splice-piece and rods are then usually covered by a sheath or cap-piece, F, Fig. 13, and the whole secured by rivets, as indicated in the drawings.

By means of the attachments D D^1 D^2, before specified, the rod may be attached to any building in the well-known manner; but instead of the tripod or common method of bracing the point-rod, or that portion elevated above the ridge of the building, I use a double rod or blank for a short distance below the point, (similar to what is shown in Fig. 1,) so as to strengthen and stiffen the rod, and make a neater and better connection between the rod and point. I also provide a series of brace-rods, G G, which may be plain, but are preferably ribbed longitudinally upon one face, which rods I rivet to the main or point rod (see Fig. 10) a short distance below the point, and then spread them out, and secure them to the roof in such a manner as to brace and sustain the point-rod. H indicates a Y or other shaped metal (preferably copper) plate, which I term a "switch," and which is so arranged as to connect the distant ends of the brace-rods with the main rod, thus completing the circuit, and facilitating the discharge of any electricity with which the brace-rods may become charged.

To the lower or ground end of the rod I connect a terminal point, which may be made substantially like the upper point, except that the silver plating would usually be omitted as simply adding to the expense and not necessary for utility or appearance.

The preceding description has been mainly directed to a single rod or blank; but one of the main advantages of the form or shape shown is, that by placing the rods or blanks

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back to back a strong and symmetric double rod is obtained, similar to what is illustrated in Fig. 1.

When the double line is used the sections may be connected by lapping or breaking joints and riveting without the use of splice-plates, but retaining the staple-rivet before described. For securing such a rod to the building the device shown in Fig. 4 has been provided.

The rod may or may not be insulated, as preferred. It is especially adapted to be used without insulation. If insulated, the single rod is supported upon and wired to an insulator having a rib to fit the groove *a'* of the flat face of the rod; the double rod would be insulated by an ordinary ring-insulator. In all cases I prefer a platinum wire in the point, as specified; but, instead of platinum, any metal the melting-point of which exceeds that of the copper may be substituted, provided such metal resists corrosion and is a good conductor.

Among the advantages of my rod are the readiness with which it may be produced by the rolls; its great strength in proportion to the contained metal; its adaptation to plain surfaces and improved general appearance; the facility and cheapness by which joints may be made without apparent interruption of the continuity of the rod, as occurs where thimbles are used; the better contact between sections obtained; the increased conducting-surface when, as in roof-rods, &c., the grooves contain water; and if lateral discharges occur, the ribs form a continuous point, which will, in case of a single rod, serve to direct the discharge away from the building.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The rod herein described, having a flat face, *a*, grooved as at *a'*, and a series of longitudinal ribs upon the reverse face, the central rib of the series projecting beyond the side ribs, substantially as specified.

2. A lightning-rod having the flat face *a*, grooved as at *a'*, and the reverse ribbed face, substantially as and for the purpose specified.

3. In combination with the sections of rod A, having grooves *a'*, the longitudinally-ribbed splice-plate, substantially as and for the purpose specified.

4. In combination with two or more sections of rod, A, having grooves *a'*, the longitudinally and transversely ribbed splice-plate, substantially as and for the purpose specified.

5. In combination with two sections of rod, A, having grooves *a'*, the longitudinally-ribbed splice-plate and staple-rivet, substantially as and for the purpose specified.

6. In combination with two or more sections of rod, A, having grooves *a'*, the longitudinally and transversely ribbed splice-plate, and the cap or sheath, substantially as and for the purpose specified.

7. The combination of the upright or point rod and the brace-rods G G, connected directly to the point-rod, substantially as and for the purpose specified.

8. The combination of the upright or point rod, the brace-rods connected thereto, and the switch, substantially as and for the purpose specified.

9. A lightning-rod point provided with a central wire of platinum throughout its length, substantially as and for the purpose specified.

10. In combination with a lightning-rod, a terminal or ground point, properly tipped and protected with platinum or other suitable metal, substantially as and for the purpose specified.

11. A lightning-rod point provided with a platinum tip cast therein, as and for the purpose set forth.

In testimony whereof I, the said JOHN J. COLE, have hereunto set my hand.

JOHN J. COLE.

Witnesses:
F. W. RITTER, Jr.,
JAMES I. KAY.

AETHERFORCE

W. W. PATTERSON.
LIGHTNING-RODS.

No. 193,991. Patented Aug. 7, 1877.

Fig. 1

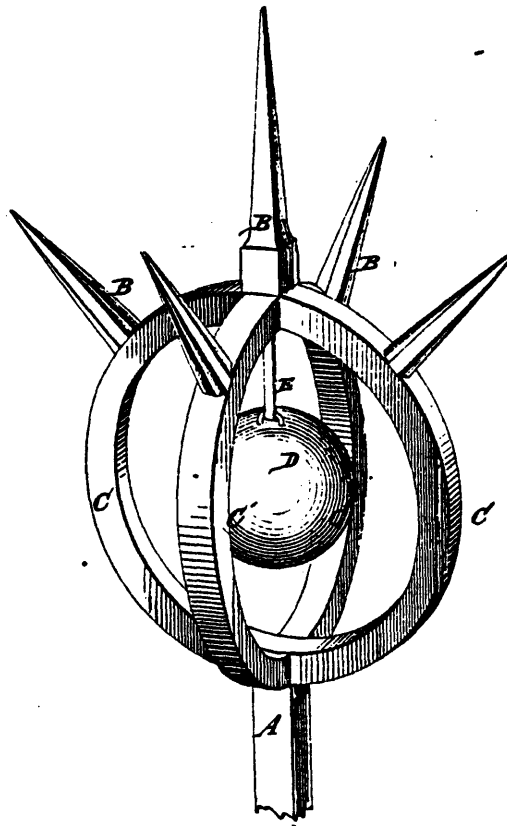
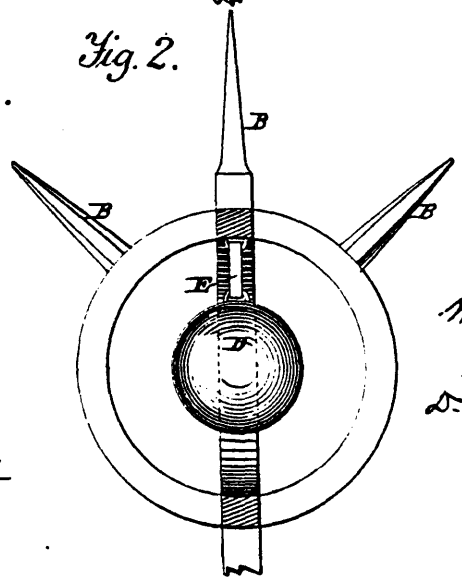


Fig. 2.



Witnesses.
A. Ruppert.
Jno. G. Mason

W. W. Patterson
Inventor.
D. P. Holloway & Co.
Attys.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

WILLIAM W. PATTERSON, OF CORNING, IOWA.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **193,991**, dated August 7, 1877; application filed April 30, 1877.

To all whom it may concern:

Be it known that I, WILLIAM W. PATTERSON, of Corning, in the county of Adams and State of Iowa, have invented a new and useful Improvement in Lightning-Rod Tips, of which the following is a specification:

This invention has for its object the production of a lightning-rod tip, which consists of intersecting circles studded with points at various angles, and a small globe or ball suspended within this circle.

In the annexed drawings, making a part of this specification, Figure 1 is a perspective view of the tip. Fig. 2 is a vertical section.

The same letters are employed in both figures in the indication of identical parts.

The tip consists of two circles, C and C′, of silver and copper plates, placed so that their horizontal diameters shall be at right angles, both circles being studded with metallic points B B, made of the same metals as the circles. Immediately beneath the main point a magnetic ball or globe, D, is suspended by a strip of zinc, E, so that the ball will hang within the intersecting circles. A is the stem by which the tip is attached to the lightning-rod.

What I claim as my invention, and desire to secure by Letters Patent, is—

A lightning-rod tip formed by the union of two intersecting circles of metal, and having a series of points projecting therefrom at various angles, and a magnetized ball or globe suspended within the intersecting circles, substantially as set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WILLIAM W. PATTERSON.

Witnesses:

ASBURY COLLINS,

A. W. CRIPPEN.

AETHERFORCE

G. W. CAIN.
Lightning-Conductor.

No. 218,708. Patented Aug. 19, 1879.

Fig. 1.

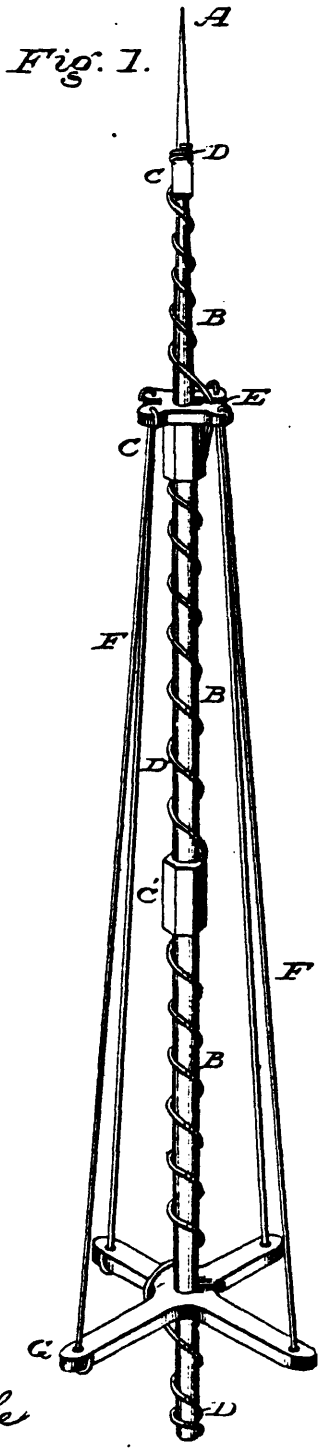


Fig. 2.

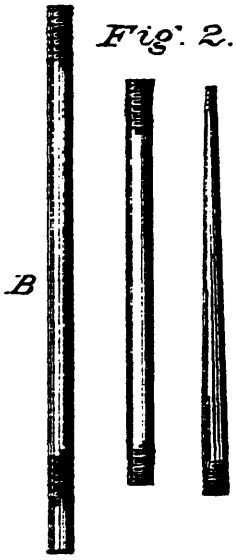


Fig. 3.

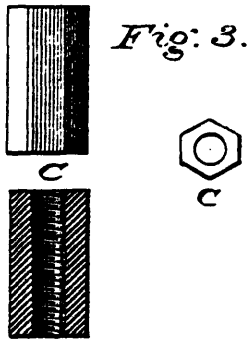
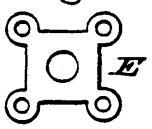


Fig. 5.



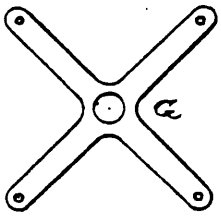


Fig. 4.

Witnesses:

Mary E. Burke

Stephen Burke

Inventor.

George W. Cain

AETHERFORCE

UNITED STATES PATENT OFFICE.

GEORGE W. CAIN, OF NEWPORT, NEW HAMPSHIRE.

IMPROVEMENT IN LIGHTNING-CONDUCTORS.

Specification forming part of Letters Patent No. **218,708**, dated August 19, 1879; application filed November 1, 1878.

To all whom it may concern:

Be it known that I, GEORGE W. CAIN, of Newport, in the county of Sullivan and State of New Hampshire, have invented a new and useful Improvement in Lightning-Conductors, of which the following is a full, clear, and concise description, reference being had to the accompanying drawings, making a part of this specification, in which the same letters indicate identical parts in the same figures.

Figure 1 is a perspective view of the conductor when ready for elevation. Fig. 2 is a view of the same in sections. Fig. 3 is a view of the coupling-boxes. Fig. 4 is a view of the point which receives the electricity. Fig. 5 is a view of the top and bottom supports of the braces.

I denominate my invention the "Independent, Isolated, Self-Supporting Lightning-Conductor."

I am aware that lightning-conductors have before been isolated from the buildings which they were designed to protect, being supported by one or more pieces of timber standing apart from said building.

My conductor is so constructed as to stand apart from the building independently of any support from outside structures or erections of timber or other material. By this means the conductor is entirely isolated from the building which it protects, and danger is thereby avoided from imperfect insulation or from moisture produced by rain or other cause; and in this consists the real point of my invention.

My improved conductor is constructed of iron, steel, copper, or other good conducting metal, as follows, viz: A is the point for receiving the electricity, and is connected by a coupling-box, C, with the upper portion or joint of the conductor B. B B′, &c., are parts or joints constructed with male screws at each end and united by the coupling-boxes C C′, &c., which are constructed with appropriate female screws, in the usual manner. D is a copper wire wound around the conductor from the point A to the end to be inserted in the ground, the design of which is to increase the conducting power of the rod. E is a collar with projecting arms, which support the upper ends of the braces F F′, &c., and G is a collar of the same form, which supports the lower ends of said braces.

The bracing-rods I also construct of copper or other good conducting metal. The base end of the conductor should be overlaid with copper, commencing immediately above the ground.

Thus constructed, the lower end of the conductor should be inserted in the ground at least eight feet deep, and from four to eight feet from the building to be protected, and the upper end or point should project from four to eight feet above the highest portion of the same building, or to a sufficient height above to protect the building.

My independent isolated conductor may be constructed of a single rod of wire or other suitable metal without joints, as above described.

Having above described my improvement in lightning-conductors, what I claim, and desire to secure by Letters Patent, is—

An independent, isolated, self-supporting lightning-conductor constructed with or without joints, as and for the purpose above described.

Witness my hand this 30th day of October, 1878.

GEORGE W. CAIN.

Witnesses:
MARY E. BURKE,
EDMUND BURKE.

ATTHEFORCE

J. C. CHAMBERS.
Insulated-Cresting.

No. 224,504. Patented Feb. 10, 1880.

Fig. 1.

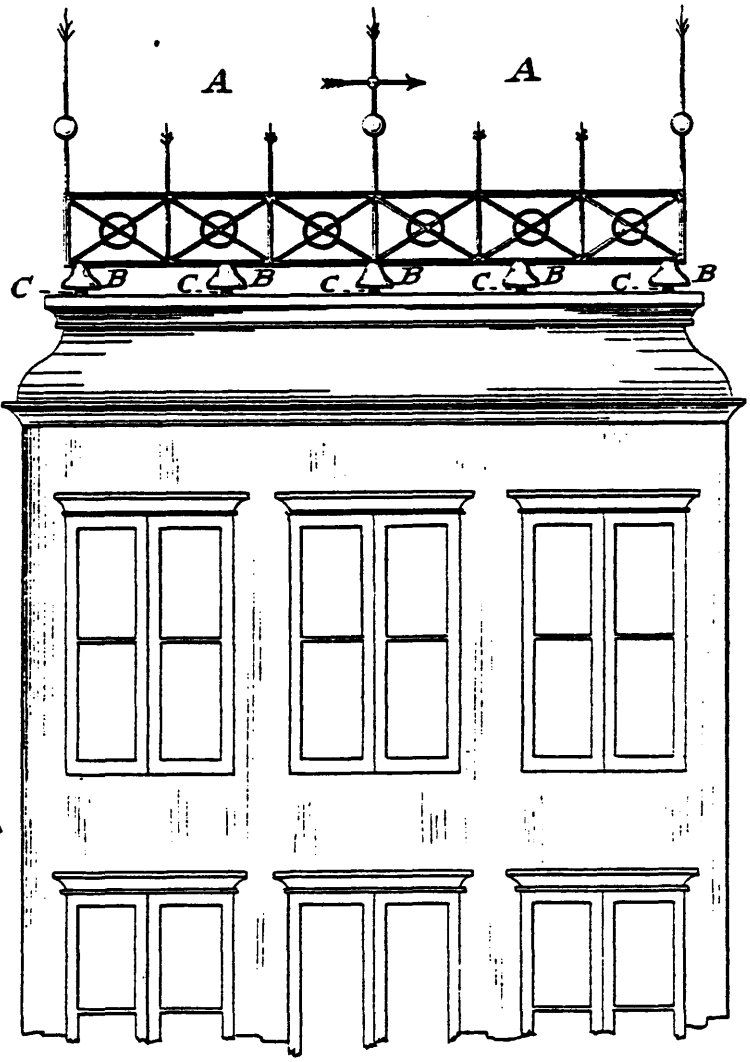
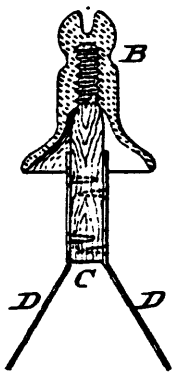


Fig. 2.



Attest
Walter Knight
Hooked Knight

Inventor
J. C. Chambers
By Knight Bros
Attys.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

JOSEPHUS C. CHAMBERS, OF CINCINNATI, OHIO, ASSIGNOR TO THE CHAMBERS NATIONAL LIGHTNING PROTECTION COMPANY, OF SAME PLACE.

INSULATED CRESTING.

SPECIFICATION forming part of Letters Patent No. 224,504, dated February 10, 1880.

Application filed November 21, 1879.

To all whom it may concern:

Be it known that I, JOSEPHUS C. CHAMBERS, of Cincinnati, in the county of Hamilton and State of Ohio, have invented a new and useful Insulated Cresting for Buildings, of which the following is a specification.

The subject of my invention is a cresting provided with numerous points, but electrically insulated both from the earth and from the building to which it is applied, so as to prevent said points affording attraction to electricity, and thus inviting a stroke of lightning, as they do when electrically connected to the building in the ordinary way.

It is well known that all bodies of conducting material, when insulated, receive electricity by induction, and the electricity so evoked is opposite from that of the body by which it was induced, while a conductor receiving electricity by conduction receives the same kind as the body from which it was obtained. It will hence appear that a cresting insulated as above described will, on the approach of a thunder-cloud, receive electricity by the inductive influence of both the earth and the cloud acting in unison upon it, developing at the same moment a pair of poles on said cresting. Supposing the cloud to be positive, the upper parts or points of the cresting will be negative, while the base, which is next the house, will be positive, the house-top being negative by reason of electrical connection with the earth.

It is manifest that a cresting thus insulated will not offer any potent attraction to the electricity in the cloud; but I am further of the opinion, based on extensive and protracted observation of such insulated crestings and rods under the influence of atmospheric electricity, that a building which the insulated cresting surrounds or surmounts is less liable to receive a stroke of lightning than another building, tree, or elevated object, or than the surrounding ground itself.

The utility of my invention is not, however, dependent on this theory, which I believe to be correct, inasmuch as it is manifest that my insulated cresting does not afford or offer to a lightning-stroke the potent attraction which is offered by crestings having electrical connection with the building to which they are applied.

The mode of carrying my invention into effect will be understood by reference to the accompanying drawings, in which—

Figure 1 is a front view or façade of a cresting, A, mounted upon insulators B, of glass or other electrical non-conductor, which insulators are securely set upon or fastened to wooden standards C erected upon the building. Fig. 2 is a partly-sectioned elevation of the insulating support such as I prefer to employ, B being the glass or other insulator proper; C, the wooden standard; D, the iron straps by which it is attached to the building.

The insulator proper, B, is bell-formed in order to shed the rain, and has a screw-socket for secure attachment to the post. It has a summit-groove to receive and hold the horizontal portion of the cresting, and a circumferential groove for the engagement of wire employed to hold said portion in the summit-groove.

I claim as new and of my invention—

1. A metallic cresting electrically insulated both from the building and from the ground, substantially as set forth.

2. A system of upturned metallic points, united and supported by horizontal portions elevated from the building, and having complete electrical insulation both from the building and from the ground, substantially as set forth.

In testimony of which invention I hereunto set my hand.

JOSEPHUS C. CHAMBERS.

Attest:
GEO. H. KNIGHT,
J. L. LOGAN.

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D. MUNSON.

LIGHTNING-RODS.

No. 184,164. Patented Nov. 7, 1876.

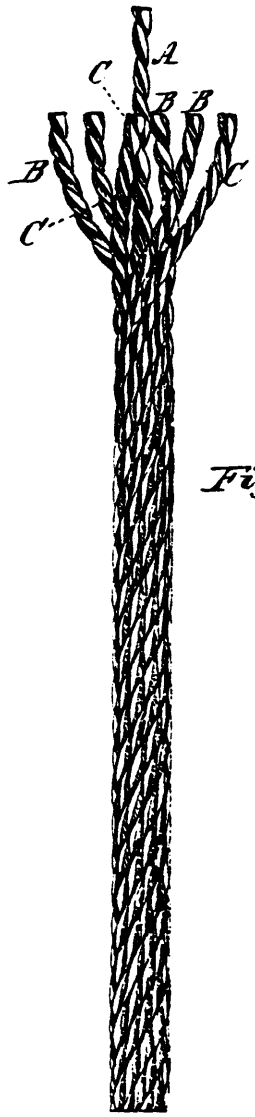
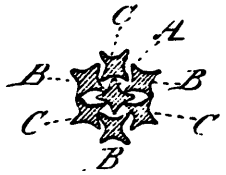


Fig. 1.

Fig. 2.



Witnesses:

J. West Wagner.

J. A. Rutherford

Inventor:

David Munson

by Johnson & Johnson

Atty's.

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

DAVID MUNSON, OF INDIANAPOLIS, INDIANA.

IMPROVEMENT IN LIGHTNING-RODS.

Specification forming part of Letters Patent No. **184,161**, dated November 7, 1876; application filed April 1, 1876.

To all whom it may concern:

Be it known that I, DAVID MUNSON, of Indianapolis, in the county of Marion and State of Indiana, have invented new and useful Improvements in Lightning-Conductors, of which the following is a specification:

My invention relates to certain novel features in the construction and arrangement of the several parts of a lightning rod or conductor, designed for the protection of buildings from the injurious and destructive effects of lightning; the nature, objects, and relations of which will be fully set forth in the following description, reference being had to the accompanying drawings, in which—

Figure 1 represents a portion of a lightning-rod constructed according to my invention; Fig. 2, a cross-section.

A is one of the rods, made of copper, which constitutes a central stem or core, around which are wound the others, B C. The rods are all formed four-sided, or, properly speaking, with four deep V-formed or concave recesses, equal in depth, so that the sections of one of the rods or strands form a Greek cross. The central core and the surrounding strands may be of exactly the same size, so that the same kind of rod may serve both for core and strand, and thus cheapen the construction. Both the core and the strands are twisted, as shown, so that the ribs of each run spirally around the rod, and present thousands of points around the cable formed of these strands, dividing the attracted electric fluid into small parts, and diminishing or destroying its compactness of body, and consequent power of injury.

I prefer the four-sided core or strand to an angular form of a less number of sides, first, because it affords a greater surface of wire in proportion to the material, and consequently saves the latter, while increasing the special efficiency of the rod by the increased number of attracting-points presented; and, secondly, because it can be more compactly wound around the core than either a round, square, or triangular form, and a greater number of points of contact between the adjacent parts of the core and of the several strands than either of the forms before mentioned, and is, externally, more nearly cylindrical in shape.

The core A and the alternate strands B I form simply of copper, without coating of any kind. The other alternate strands C I form likewise of copper; but I plate its surface with tin or nickel plating, completely covering its periphery with that metal, so that it is effectually protected from corrosion by exposure to the weather.

By plating these rods or strands C their attracting power is maintained undiminished for years, as the oxidation produced by exposure tends to insulate the several parts of the rod, and thereby diminish its efficiency.

As, however, the sole use of plated rods or strands in the formation of the rod would increase the cost of the manufactured article, I alternate the strands of plated copper C with strands B of the simple unplated metal, the conducting power of which, as it has many points throughout its length of contact with the plated strands, is preserved by this contact for a much longer period of time, as well as preserved from corrosion thereby.

The process of galvanizing metallic wire—particularly copper wire—tends to destroy those qualities of the wire which fit it for the purposes of a lightning-conductor. My use of plated wire is free from this objection.

If desired, all the strands may be plated instead of alternately; but the latter I prefer, as being more effective or economical.

The state of the art shows that sheet-copper, formed in folds or fluted, has been tinned on one side, as in my patent of February 11, 1868; and that three or more round iron wires, covered with zinc or tin, and three or more round copper wires have been laid together to form the body or core of the rod without a central core, the copper wires being laid between the iron-plated wires in rope form at the outside of the rod, so as to bring an iron-plated wire between any two adjacent copper wires, as in the patent of Cushman, of March 7, 1871. An iron core, of angular cross-section, incased in a copper strip, and twisted to present sharp edges, has been used, as in the patent of Vermilya, Reyburn, and Hunter, of July 13, 1869. Several strands of copper wire, of triangular or square cross-section, have been twisted round each other to form a rope without a central core, as in the patent

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of Otis, of July 21, 1868. A central straight copper core, of circular cross-section, surrounded by three or more twisted iron wires of the same form, has been used, as in the patent of M. D. Phelps, of December 19, 1871; while in the patents granted to me June 23, 1872, I have combined a plurality of angular copper wires, each separate wire being twisted round its own axis, and a number of such twisted wires formed into a rope, and a number of such ropes twisted round each other, and in which such twisted wire ropes have been laid around an iron core, of circular cross-section, and in which two or more separate and distinct ropes of such angular twisted copper wires have been combined with a like number of iron core-rods, of circular cross-section, both being intertwisted with each other. These forms of conductors, as patented to me, have been shown to produce good results; but my present improvements are designed to render them still more perfect.

It is important that the metal used for lightning-rods should be as rough and sharp-cornered as possible, to give it the best receiving-power; and hence I have combined such a sharp-cornered core with sharp-cornered outer wires, so that both the interior and exterior shall present innumerable sharp lines throughout the rod. Copper is the best metal for lightning-rods, and the square form is the safest; hence I employ a copper core, of four-edged form and twisted, to obtain the best effect by interior and exterior sharp points, as the lightning-discharges spread immediately over the whole surface of twisted points, and thereby become weakened.

The plating of the twisted strands gives an important advantage in keeping the spaces between the sharp folds of the wires clean and smooth.

I claim—

A lightning-rod in which are combined a central core, A, of twisted copper wire, having four recessed sides, forming receiving-edges, and strands B C of similar shaped and twisted copper wire, twisted spirally around said twisted core, each said alternate twisted wire being plated, the whole forming a new lightning-conductor, as herein set forth.

In testimony whereof I have affixed my signature in the presence of two witnesses.

DAVID MUNSON.

Witnesses:

J. A. RUTHERFORD,

J. WEST WAGNER.

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N. TESLA.

LIGHTNING PROTECTOR.

APPLICATION FILED MAY 6, 1916.

1,266,175. Patented May 14, 1918.

Fig. 1.

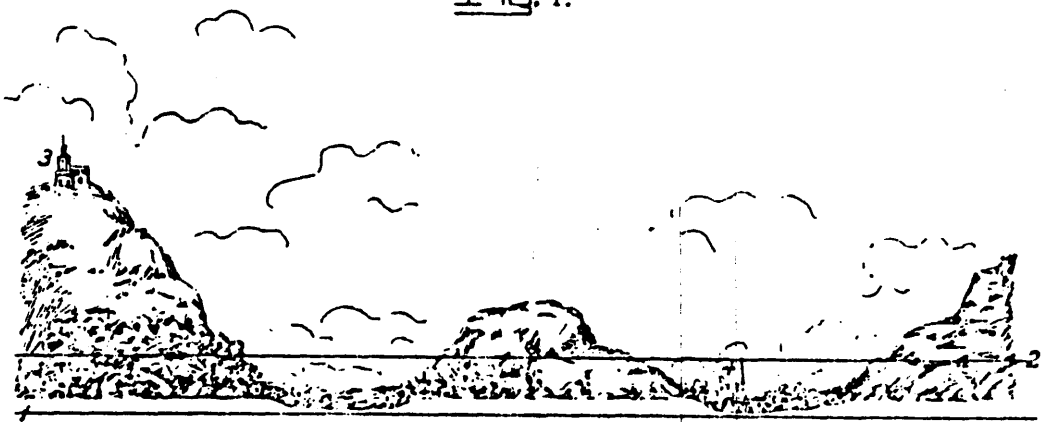


Fig. 2.

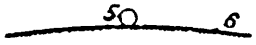


Fig. 3.

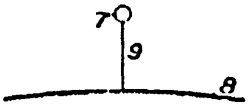


Fig. 4.

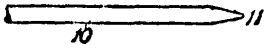


Fig. 5.

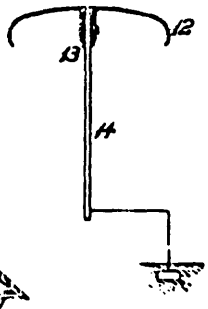


Fig. 6.

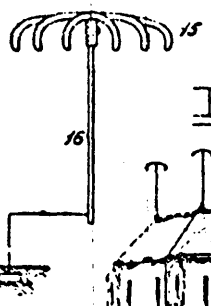


Fig. 7.

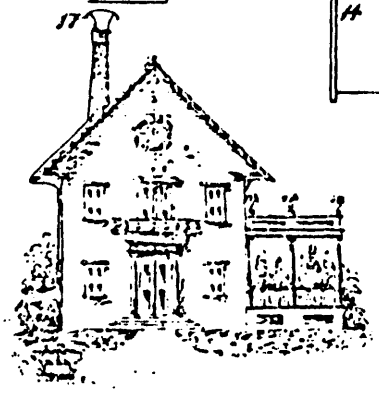
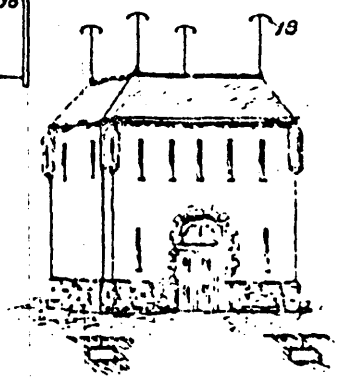


Fig. 8.



WITNESSES:

John B. McIlhenny

William P. Johnson

INVENTOR.

Nikola Tesla

BY Kerr, Page, Cooper & Hayward

ATTORNEYS

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UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

LIGHTNING-PROTECTOR.

1,266,175. Specification of Letters Patent. Patented May 14, 1918.

Application filed May 6, 1916. Serial No. 95,830.

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Lightning-Protectors, of which the following is a full, clear, and exact description.

The object of the present invention is to provide lightning protectors of a novel and improved design strictly in conformity with the true character of the phenomena, more efficient in action, and far more dependable in safe-guarding life and property, than those heretofore employed.

To an understanding of the nature of my invention and its basic distinction from the lightning rods of common use, it is necessary briefly to explain the principles upon which my protector is designed as contrasted with those underlying the now-prevailing type of lightning rod.

Since the introduction of the lightning rod by Benjamin Franklin in the latter part of the eighteenth century, its adoption as a means of protection against destructive atmospheric discharges has been practically universal. Its efficacy, to a certain degree, has been unquestionably established through statistical records but there is generally prevalent, nevertheless, a singular theoretical fallacy as to its operation, and its construction is radically defective in one feature, namely its typical pointed terminal. In my lightning protector I avoid points, and use an entirely different type of terminal.

According to the prevailing opinion, the virtue of the Franklin type of lightning rod is largely based on the property of points or sharp edges to give off electricity into the air. As shown by Coulomb, the quantity of electricity per unit area, designated by him "electrical density" increases as the radius of curvature of the surface is reduced. Subsequently it was proved, by mathematical analysis, that the accumulated charge created an outward normal force equal to 2π times the square of the density, and experiment has demonstrated that when the latter exceeds approximately 20 C. G. S. units, a streamer or corona is formed. From these observations and deductions it is obvious that such may happen at a comparatively low pressure if the conductor is of extremely small radius, or pointed, and it is pursuant to a misapplication of these, and other, truths that the commercial lightning rod of today is made very slender and pointed. My invention, on the contrary, while taking cognizance of these truths, correctly applies them in the provision of a lightning protector that distinctively affords an elevated terminal having its outer conducting boundaries arranged on surfaces of large radii of curvature on two dimensions. The principles which underlie my invention and correct application of which dictate the form and manner of installation of my protector, I will now explain in contrast with the conventional pointed lightning rod.

In permitting leakage into the air, the needle-shaped lightning-rod is popularly believed to perform two functions: one to drain the ground of its negative electricity, the other to neutralize the positive of the clouds. To some degree it does both. But a systematic study of electrical disturbances in the earth has made it palpably evident that the action of Franklin's conductor, as commonly interpreted, is chiefly illusionary. Actual measurement proves the quantity of electricity escaping even from many points, to be entirely insignificant when compared with that induced within a considerable terrestrial area, and of no moment whatever in the process of dissipation. But it is true that the negatively charged air in the vicinity of the rod, rendered conductive through the influence of the same, facilitates the passage of the bolt. Therefore it increases the probability of a lighting discharge in its vicinity. The fundamental facts underlying this type of lightning-rod are: First, it attracts lightning, so that it will be struck oftener than would be the building if it were not present; second, it renders harmless most, but not all, of the discharges which it receives; third, by rendering the air conductive, and for other reasons, it is sometimes the cause of damage to neighboring objects; and fourth, on the whole, its power of preventing injury predominates, more or less, over the hazards it invites.

My protector, by contrast, is founded on principles diametrically opposite. Its terminal has a large surface. It secures a very low density and preserves the insulating qualities of the ambient medium, thereby

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minimizing leakage, and in thus acting as a quasi-repellant to increase enormously the safety factor.

For the best and most economical installation of protective devices according to my invention, those factors and phenomena that dictate size, number of protectors and physical qualities of the apparatus must be grasped by the installing engineer, and preliminarily, for full understanding of the principles of my invention, these should be briefly explained.

Economical installation, of course, demands that the protective capability of any given equipment be not needlessly greater than is required to meet the maximum expectancies under the conditions surrounding the particular building to be protected, and these depend, partially, as I shall show, upon the character of the landscape proximate to the building site.

In the drawings, Figures 1 to 4 inclusive, are diagrams requisite to illustration of the facts and conditions relevant to the determination of specific installations of my invention, and Figs. 5 to 8 illustrate construction and application of the protectors. Specifically:

Fig. 1 is a landscape suited for purpose of explanation; Figs. 2, 3 and 4 are theoretical diagrams; Figs. 5 and 6 illustrate forms of improved protectors; and Figs. 7 and 8 show buildings equipped with the same.

In Fig. 1, 1 represents Lord Kelvin's "reduced" area of the region, which is virtually part of the extended unruffled ocean-surface. (See "*Papers on Electrostatics and Magnetism*" by Sir William Thomson). Under ordinary weather conditions, when the sky is clear, the total amount of electricity distributed over the land is nearly the same as that which would be contained within its horizontal projection. But in times of storm, owing to the inductive action of the clouds, an immense charge may be accumulated in the locality, the density being greatest at the most elevated portions of the ground. Assuming this, under the conditions existing at any moment, let another spherical surface 2, concentric with the earth, be drawn—which may be called "electrical niveau"—such that the quantities stored over and under it are equal. In other words, their algebraic sum, taken relatively to the imaginary surface, in the positive and negative sense, is *nil*. Objects above the "niveau" are exposed to ever so much more risk than those below. Thus, a building at 3, on a site of excessive density, is apt to be hit sooner or later, while one in a depression 4, where the charge per unit area is very small, is almost entirely safe. It follows that the one building 3 requires more extensive equipment than does the other. In both instances, however, the probability of being struck is decreased by the presence of my protector, whereas it would be increased by the presence of the Franklin rod, for reasons that I will now explain.

An understanding of but part of the truths relative to electrical discharges, and their misapplication due to the want of fuller appreciation has doubtless been responsible for the Franklin lightning rod taking its conventional pointed form, but theoretical considerations, and the important discoveries that have been made in the course of investigations with a wireless transmitter of great activity by which arcs of a volume and tension comparable to those occurring in nature were obtained ("Problems of Increasing Human Energy" *Century Magazine* June 1900 and Patents 645,576, 649,621, 787,412 and 1,119,732) at once establish the fallacy of the hitherto prevailing notion on which the Franklin type of rod is based, show the distinctive novelty of my lightning protector, and guide the constructor in the use of my invention.

In Fig. 2, 5 is a small sphere in contact with a large one, 6, partly shown. It can be proved by the theory of electric images that when the two bodies are charged the mean density on the small one will be only

$$\frac{\pi^2}{6} = 1.64493$$

times greater than that on the other. (See "*Electricity and Magnetism*" by Clerk Maxwell). In Fig. 3, the two spheres 7 and 8 are placed some distance apart and connected through a thin wire 9. This system having been excited as before, the density on the small sphere is likely to be many times that on the large one. Since both are at the same potential it follows directly that the densities on them will be inversely as their radii of curvature. If the density of 7 be designated as d and the radius r, then the charge $q=4\pi r^2 d$, the potential $p=4\pi r d$ and the outward force, normal to the surface, $f=2\pi d^2$. As before stated, when d surpasses 20 C. G. S. units, the force f becomes sufficiently intense to break down the dielectric and a streamer or corona appears. In this case $p=80\pi r$. Hence, with a sphere of one centimeter radius disruption would take place at a potential $p=80\pi=251.328$ E. S. units, or 75,398.4 volts. In reality, the discharge occurs at a lower pressure as a consequence of uneven distribution on the small sphere, the density being greatest on the side turned away from the large one. In this respect the behavior of a pointed conductor is just the reverse. Theoretically, it might erroneously be inferred from the preceding, that sharp projections would permit electricity to escape at the lowest potentials, but this does not follow. The reason will be clear from an inspection of Fig.

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4, in which such a needle-shaped conductor 10, is illustrated, a minute portion of its tapering end being marked 11. Were this portion removed from the large part 10 and electrically connected with the same through an infinitely thin wire, the charge would be given off readily. But the presence of 10 has the effect of reducing the capacity of 11, so that a much higher pressure is required to raise the density to the critical value. The larger the body, the more pronounced is this influence, which is also dependent on configuration, and is maximum for a sphere. When the same is of considerable size it takes a much greater electromotive force than under ordinary circumstances to produce streamers from the point. To explain this apparent anomaly attention is called to Fig. 3. If the radii of the two spheres, 7 and 8, be designated r and R respectively, their charges q and Q and the distance between their centers D, the potential at 7, due to Q is $\frac{Q}{D}$. But 7, owing to the metallic connection 9, is at the potential

$$\frac{Q}{R}=\frac{q}{r}.$$

When D is comparable to R, the medium surrounding the small sphere will ordinarily be at a potential not much different from that of the latter and millions of volts may have to be applied before streamers issue, even from sharp protruding edges. It is important to bear this in mind, for the earth is but a vast conducting globe. It follows that a pointed lightning-rod must be run far above ground in order to operate at all, and from the foregoing it will be apparent that the pointing of the end, for supposed emissive effect, is in part neutralized by the increasing size below the extreme end, and the larger the rod, for reduction of electrode resistance, the more pronounced is this counter-influence. For these reasons it is important to bear in mind that sufficient thickness of the rod for very low electrode-resistance is rather incompatible with the high emissive capability sought in the needle-like Franklin-rod, but, as hereinafter set forth, it is wholly desirable in the use of my invention, wherein the terminal construction is intended for suppression of charge-emission rather than to foster it.

The notion that Franklin's device would be effective in dissipating terrestrial charges may be traced to early experiments with static frictional machines, when a needle was found capable of quickly draining an insulated electrified body. But the inapplicability of this fact to the conditions of lightning protection will be evident from examination of the simple theoretical principles involved, which at the same time substantiate the desirability of establishing protection by avoiding such drainage. The density at the pointed end f should be inversely as the radius of curvature of the surface, but such a condition is unrealizable. Suppose Fig. 4 to represent a conductor of radius 100 times that of the needle; then, although its surface per unit length is greater in the same radio, the capacity is only double. Thus, while twice the quantity of electricity is stored, the density on the rod is but one-fiftieth of that on the needle, from which it follows that the latter is far more efficient. But the emissive power of any such conductor is circumscribed. Imagine that the "pointed" (in reality blunt or rounded) end be continuously reduced in size so as to approximate the ideal more and more. During the process of reduction, the density will be increasing as the radius of curvature gets smaller, but in a proportion distinctly less than linear; on the other hand, the area of the extreme end, that is, the section through which the charge passes out into the air, will be diminishing as the square of the radius. This relation alone imposes a definite limit to the performance of a pointed conductor, and it should be noticed that the electrode resistance would be augmented at the same time. Furthermore, the efficacy of the rod is much impaired through potential due to the charge of the ground, as has been indicated with reference to Fig. 3. Practical estimates of the electrical quantities concerned in natural disturbances show, moreover, how absolutely impossible are the functions attributed to the pointed lightning conductor. A single cloud may contain 2×10^{12} C. G. S. units, or more, inducing in the earth an equivalent amount, which a number of lightning rods could not neutralize in many years. Particularly to instance conditions that may have to be met, reference is made to the *Electrical World* of March 5, 1904, wherein it appears that upon one occasion approximately 12,000 strokes occurred within two hours within a radius of less than 50 kilometers from the place of observation.

But although the pointed lightning-rod is quite ineffective in the one respect noted, it has the property of attracting lightning to a high degree, firstly on account of its shape and secondly because it ionizes and renders conductive the surrounding air. This has been unquestionably established in long continued tests with the wireless transmitter above-mentioned, and in this feature lies the chief disadvantage of the Franklin type of apparatus.

All of the foregoing serves to show that since it is utterly impracticable to effect an equalization of charges emissively through pointed lightning-rods under the conditions presented by the vast forces of nature great

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improvement lies in the attainment of a minimized probability of lightning stroke to the area to be protected coupled with adequate conductivity to render harmless those strokes that may, notwithstanding, occur.

Furthermore, a correct application of the truths that have thus been explained with reference to the familiar pointed type of lightning-rod not only substantiates the theoretical propriety of the form in which I develop my improved lightning protector, but will lead the installing engineer properly to take cognizance of those conditions due to location of the building, with respect to surrounding earth formations and other buildings, probabilities of maximum potential-differences and charge-densities to be expected under the prevailing atmospheric conditions of the site, and desirable electrode resistance and capacities of the protectors installed.

The improved protector, as above stated, behaves in a manner just opposite to the Franklin type and is incomparably safer for this reason. The result is secured by the use of a terminal or conducting surface of large radius of curvature and sufficient area to make the density very small and thereby prevent the leakage of the charge and the ionization of the air. The device may be greatly varied in size and shape but it is essential that all its outer conducting elements should be disposed along an ideal enveloping surface of large radius and that they should have a considerable total area.

In Fig. 5, Fig. 6, Fig. 7 and Fig. 8, different kinds of such terminals and arrangements of same are illustrated. In Fig. 5, 12 is a cast or spun metal shell of ellipsoidal outlines, having on its under side a sleeve with a bushing 13 of porcelain or other insulating material, adapted to be slipped tightly on a rod 14, which may be an ordinary lightning conductor. Fig. 6 shows a terminal 15 made up of rounded or flat metal bars radiating from a central hub, which is supported directly on a similar rod and in electrical contact with the same. The special object of this type is to reduce the wind resistance, but it is essential that the bars have a sufficient area to insure small density, and also that they are close enough to make the aggregate capacity nearly equal to that of a continuous shell of the same outside dimensions. In Fig. 7 a cupola-shaped and earthed roof is carried by a chimney, serving in this way the twofold practical purpose of hood and protector. Any kind of metal may be used in its construction but it is indispensable that its outer surface should be free of sharp edges and projections from which streamers might emanate. In like manner mufflers, funnels and vents may be transformed into effective lightning protectors if equipped with suitable devices or designed in conformity with this invention. Still another modification is illustrated in Fig. 8 in which, instead of one, four grounded bars are provided with as many spun shells or attachments 18, with the obvious object of reducing the risk.

From the foregoing it will be clear that in all cases the terminal prevents leakage of electricity and attendant ionization of the air. It is immaterial to this end whether it is insulated or not. Should it be struck the current will pass readily to the ground either directly or, as in Fig. 5, through a small air-gap between 12 and 14. But such an accident is rendered extremely improbable owing to the fact that there are everywhere points and projections on which the terrestrial charge attains a high density and where the air is ionized. Thus the action of the improved protector is equivalent to a repellant force. This being so, it is not necessary to support it at a great height, but the ground connection should be made with the usual care and the conductor leading to it must be of as small a self-induction and resistance as practicable.

I claim as my invention:

1. A lightning protector consisting of an elevated terminal, having its outer conducting boundaries arranged on surfaces of large radii of curvature in both dimensions, and a grounded conductor of small self-induction, as set forth.

2. A lightning protector composed of a metallic shell of large radius of curvature, and a grounded conductor of small self-induction, as described.

3. Apparatus for protection against atmospheric discharges comprising an earth connection of small resistance, a conductor of small self-induction and a terminal carried by the same and having a large radius of curvature in two dimensions as, and for the purpose set forth.

4. In apparatus for protection against atmospheric discharges an insulated metallic shell of large radius of curvature supported by a grounded conductor and separated from the same through a small air-gap as, and for the purpose described.

5. A lightning protector comprising, in combination, an elevated terminal of large area and radius of curvature in two dimensions, and a grounded conductor of small self-induction, as set forth.

6. In apparatus for protection against lightning discharges, the combination of an elevated metallic roof of large area and radius of curvature in two dimensions, and a grounded conductor of small self-induction and resistance, as described.

7. As an article of manufacture a metallic shell of large radius of curvature provided with a sleeve adapted for attachment

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to a lightning rod as, and for the purpose set forth.

8. A lightning protector comprising an ellipsoidal metallic shell and a grounded conductor of small self-induction, as set forth.

9. In apparatus for protection against atmospheric discharges a cupola-shaped metallic terminal of smooth outer surface, in combination with a grounded conductor of small self-induction and resistance, as described.

In testimony whereof I affix my signature.

NIKOLA TESLA.

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Gilded copper arrow vane of latter half of nineteenth century is on store in Shelburne, Vermont.

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Improved Lightning-Rod.

This form of lightning-rod is of the non-insulated class, and is constructed of pure, cold-rolled Lake superior copper. The conductor itself is of a flat form as shown in the engraving, and is fastened in close contact with the building it is intended to protect. It is continuous in length, and is supported at various intervals by straps of the same material nailed to the house, the ends of the straps being turned over as in Fig. 3, to make a neat appearance. The upper portion of the rod may be coiled up in a tubular form, as shown in Fig. 2, to compose the tip and point; the flat shape also permits the conductor to be easily rolled up for transportation. The fact of this conductor being continuous throughout its entire length, without a joint, is a valuable feature, as electricity passes over a smooth surface much more readily than where joints or breaks occur. The close connection between the conductor and the building, the inventor states, is a safeguard against ascending as well as descending currents, and it is claimed that the general arrangement of this continuous non-insulated conductor is safer, much more convenient for adjustment and transportation, than those ordinarily in use. A patent is now pending on this invention through the Scientific American Patent Agency. For further information address the inventor, N. Brittan, Chicago, Ill.

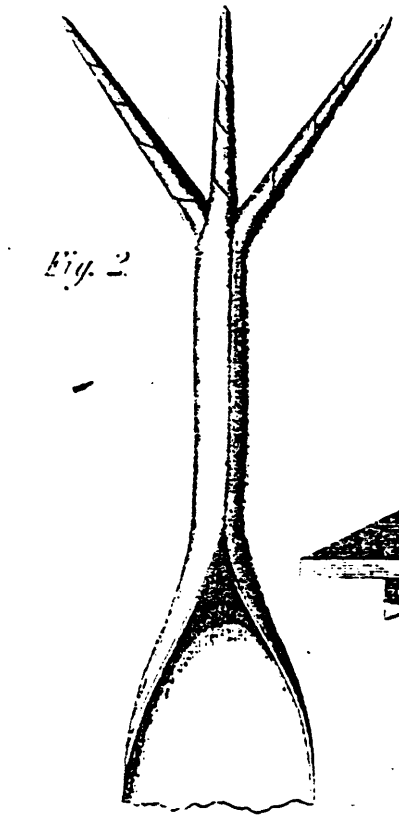

Fig. 2

Fig. 3

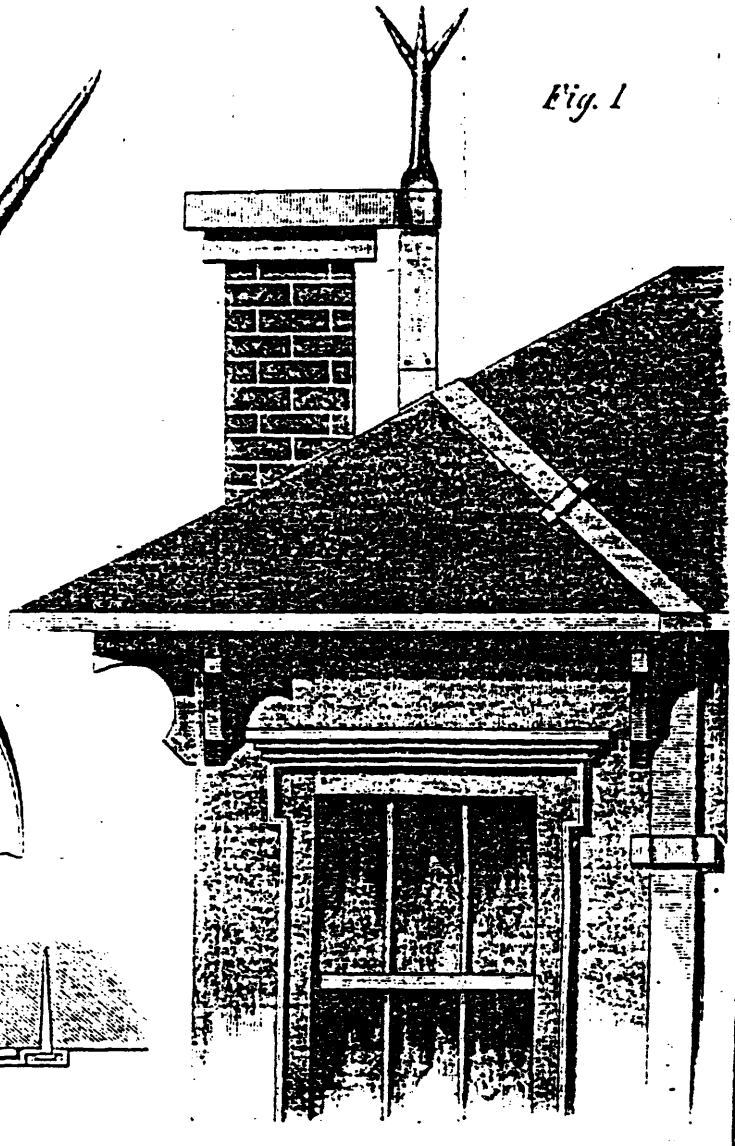

Fig. 1

BRITTAN'S IMPROVED LIGHTNING-ROD.

diseases the most prolonged, the most fatal. The suns of our best men go down at noon, and so accustomed are we to the phenomenon that we cease to regard it as either strange or out of place. It is through the mind now that the body is destroyed by overwork; at all events, it is so mainly. The men of intense thought—men of letters, men of business who think and speculate, men of the state who are ambitious to rule, these men are sacrifices. With them the brain has not merely to act on its own muscles, bidding them perform their necessary duties, but the one brain must needs guide a hundred other

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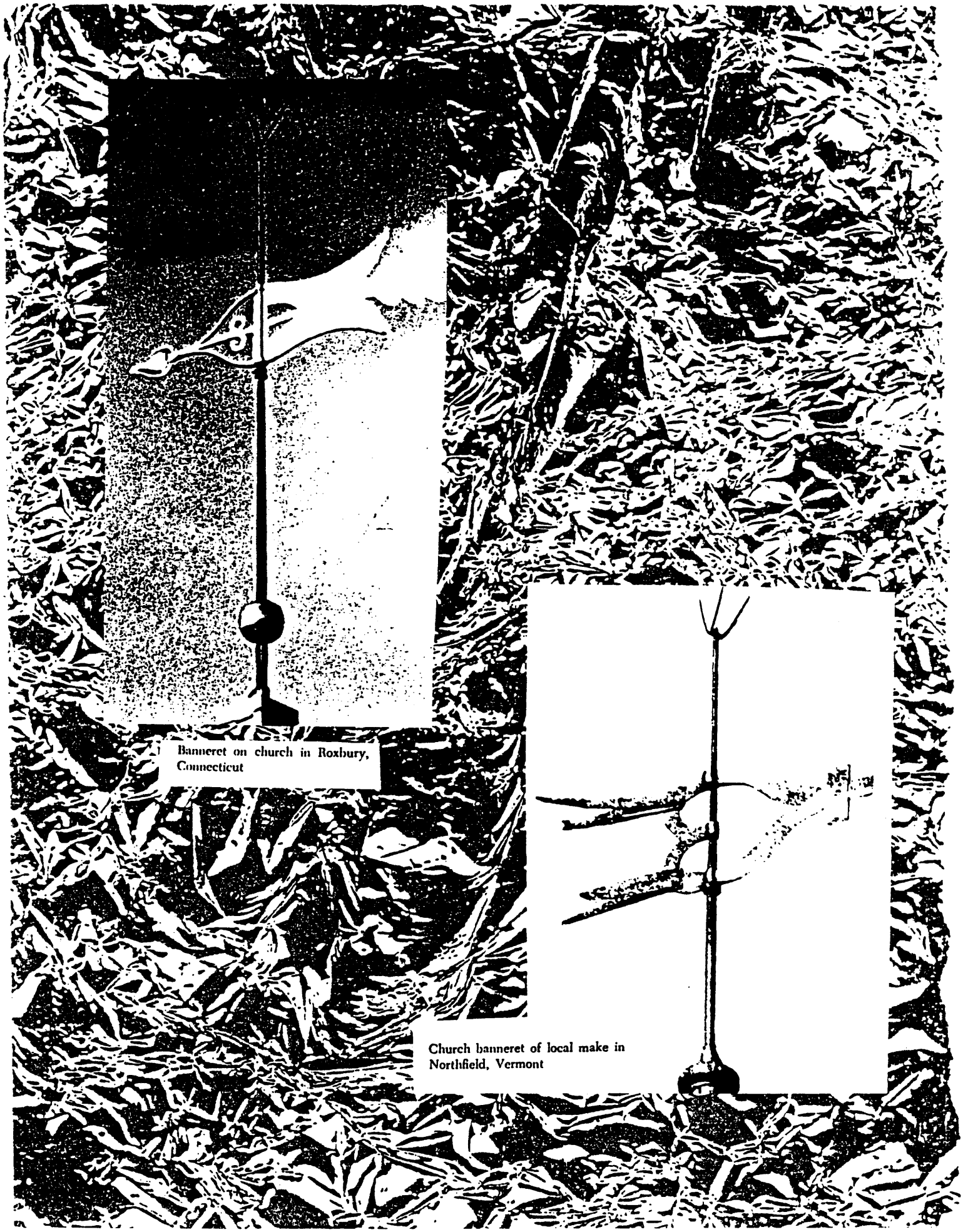

Banneret on church in Roxbury, Connecticut

Church banneret of local make in Northfield, Vermont

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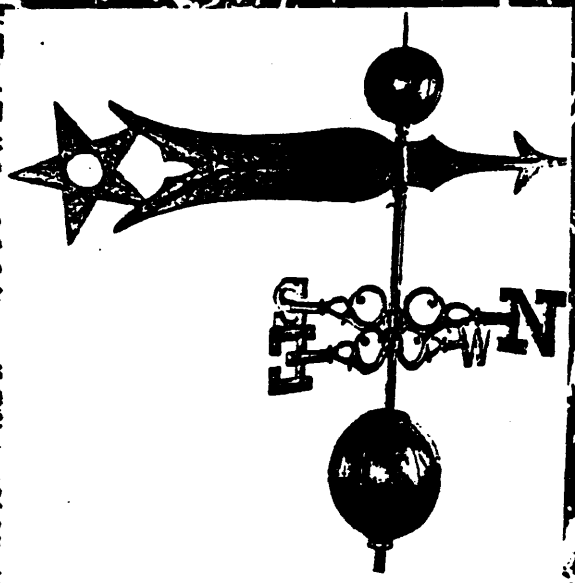
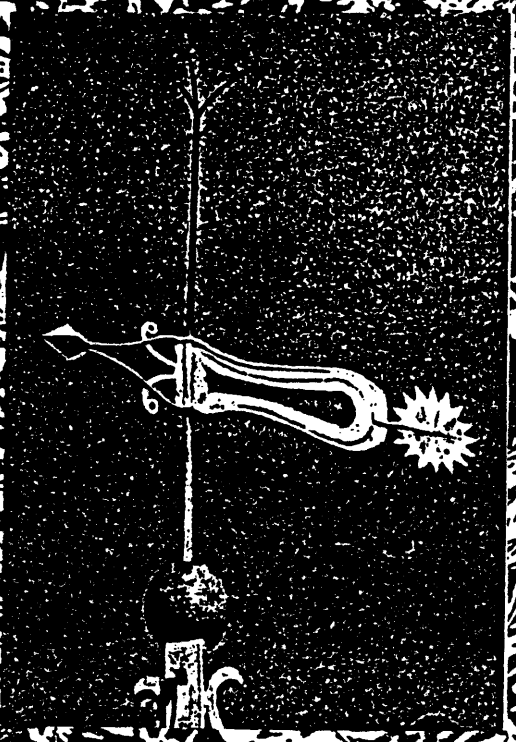
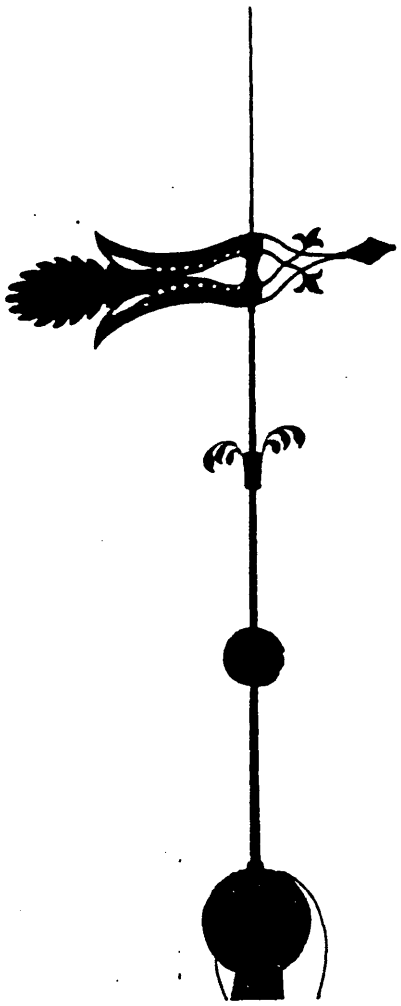


Arrow and star vane is from Mutual Fire Insurance Building in Montpelier, Vermont. Made in mid-nineteenth century, it is gilded iron. (*Shelburne Museum*)





The First Congregational Church in Woodbury, Connecticut, also has a handsome banneret vane with piercing to vary the design.

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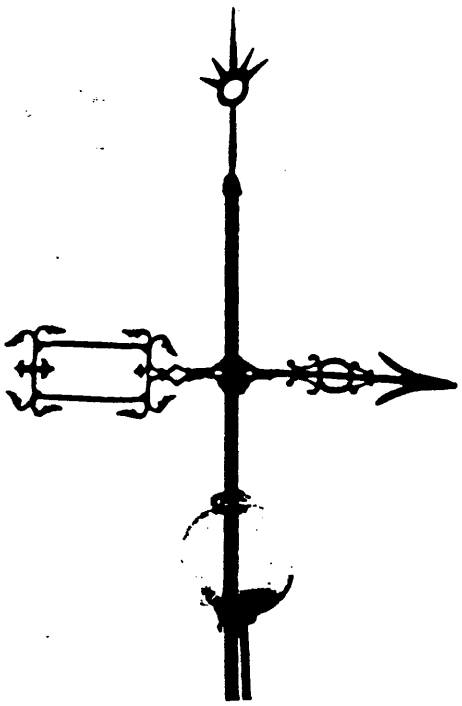
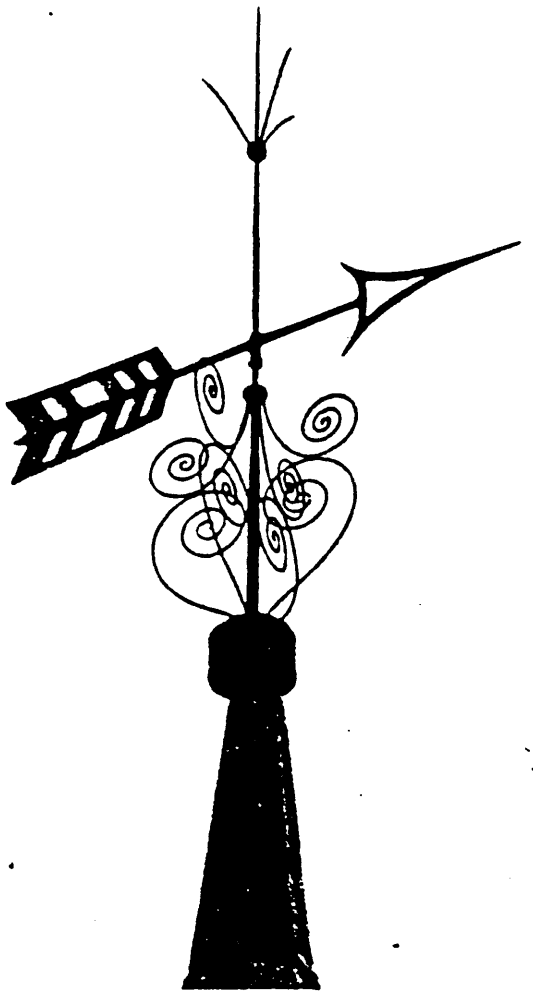
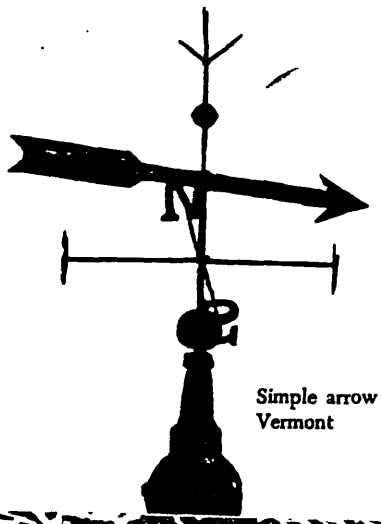


Banneret–arrow vane with glass ball on shaft is on barn in East Braintree, Vermont. Vane is also lightning rod.



Arrow with intricate scrollwork on church in Williamstown, Vermont



Simple arrow vane on church in Sharon, Vermont

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C. F. Varley. Impt in Electric Telegraphs.

75492

Fig: 1.

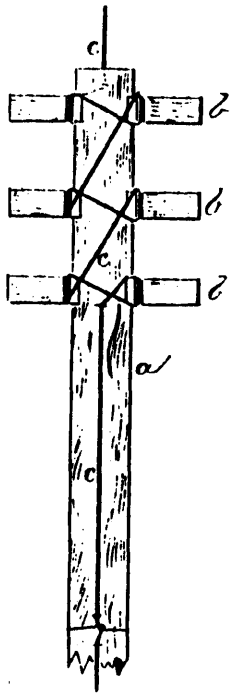
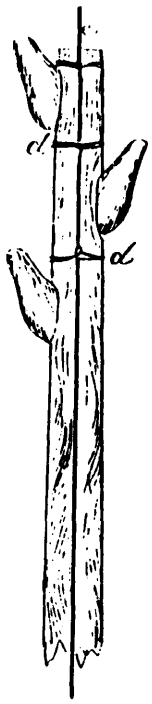


Fig: 2.



PATENTED
MAR 10 1868

Witnesses
Wm H Bishop
A. de Lacy

C F Varley.

ATHEROE

UNITED STATES PATENT OFFICE.

C. F. VARLEY, OF NEW YORK, N. Y.

IMPROVEMENT IN TELEGRAPH-POLES.

Specification forming part of Letters Patent No. **75,192**, dated March 10, 1868.

To all whom it may concern:

Be it known that I, CROMWELL FLEETWOOD VARLEY, a British subject, now residing in the city, county, and State of New York, have invented a new and useful Improvement in Electric Telegraphs; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, making part of this specification, in which—

Figure 1 is an elevation of a pole for holding the telegraphic wires, with my said improvement applied thereto, and Fig. 2 an elevation of a modification thereof.

In telegraphic lines consisting of more than one conducting-wire, in case of a "leak" in any one wire by reason of any imperfection in the insulators, the current thus leaking is liable to run to the other wires, or some of them, and thereby to produce a disturbance in the messages transmitted.

The object of my said invention is to avoid the difficulty above stated, which consists in combining with the pole which sustains the wires and with the insulators attached thereto a conducting-wire extending into the ground for conducting off and discharging such leak, and thereby prevent it from reaching the other wires.

In Fig. 1 of the accompanying drawings, *a* represents an ordinary telegraph-pole with cross-arms *b*, to which the insulators are attached. To this pole I secure a conducting-wire, *c*, which is secured to the upper part of the pole, and which may be provided with a point projecting upward to act as a lightning-rod to receive and discharge electricity from the atmosphere. It is then wrapped around the upper one of the arms *b*, on one side of the pole; then to and around the arm *b* on the opposite side, and then, crossing the pole, down to the second arm, *b*, wrapped around that on one side of the pole, and then around the same arm on the other side of the pole, and, in like manner, around the other arms, and, finally, down into the ground.

I prefer to indent or notch the arms where the wire is wrapped around them, to prevent currents from being conducted under the wire by moisture lodging on the surface of the arms in case the wires should not be in contact.

When the poles are made without arms, and with the insulators attached directly to the poles, as represented in Fig. 2 of the accompanying drawings, the wire *c* should be wrapped around the pole between the several insulators, as at *d*, and then run down into the ground, and when so applied I prefer to indent the pole where the wire is wrapped around it, and for the reason stated above as to the indenting of the arms.

What I claim as my invention, and desire to secure by Letters Patent, is—

The combination of a conducting-wire running to the ground with the telegraph-pole and the insulators attached thereto, substantially as and for the purpose set forth.

C. F. VARLEY.

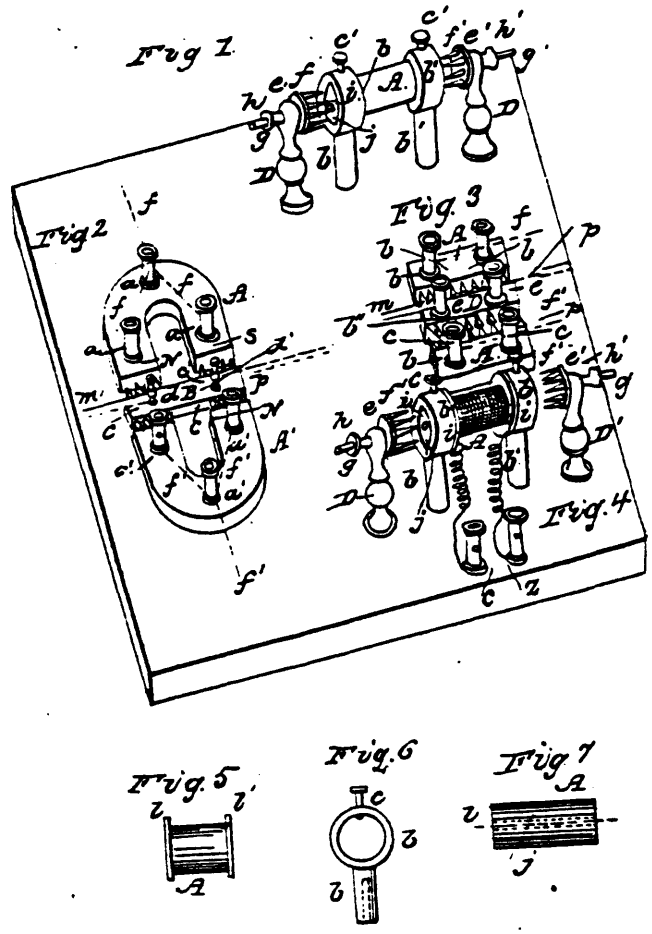
Witnesses:
WM. H. BISHOP,
A. DE LACY.

ÆTHERFORCE

A. BARBARIN.

Lightning Arreste

No. 68,407. Patented Sept. 3, 1867.



Witnesses
Rufus R Rhodes
H W Jenkins

Inventor
Arthur Barbarin

ÆTHERFORCE

United States Patent Office.

ARTHUR BARBARIN, OF NEW ORLEANS, LOUISIANA.

Letters Patent No. 68,407, *dated September* 3, 1867.

IMPROVEMENT IN LIGHTNING-ARRESTERS.

The Schedule referred to in these Letters Patent and making part of the same.

TO ALL WHOM IT MAY CONCERN:

Be it known that I, ARTHUR BARBARIN, of the city of New Orleans, and State of Louisiana, have invented a certain new, useful, and "Improved Magnetic Lightning-Arrester," for telegraphs, cables, &c.; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the annexed drawings, making a part of this specification.

It is well known that "lightning-arresters" for telegraghs, cables, &c., have for some time attracted the serious attention of telegraphers, and many have been produced, used a short time, and thrown aside because found insufficient to answer the purpose for which they were intended.

The main or great point to arrive at is to create an arrester with the power at all times to carry off the great bulk of "atmospheric electricity" to the ground before it reaches the helix of a magnet or passes through a cable by which the complete or partial destruction of either is prevented and the operator saved from injury; in other words, to separate the "atmospheric" from the "battery" electricity without interfering with the passage of the latter to its destination. This I believe can be fully achieved by the use and application of permanent magnets, or of electro-magnetism to telegraph arresters, in lieu of the ordinary unmagnetized metal plates, or other method now in use.

In Figure 1, A is a steel magnetized bar or rod forming a straight permanent magnet. This magnet is supported by two metal supports, *b b* and *b' b'*, having on their top two thumb-screws, *c* and *c'*, to secure or clasp the ends of the bar or magnet when the same is placed (as shown on the drawings, fig. 1,) through the ring or neck of the supports, (see Figure 6,) and to form at the same time a reliable connection with the ground by means of wires or metal bands connected thereto through their binding-screws. (These screws are not shown on the drawings, but they are a well-known appliance used everywhere.) D and D' are two metal pillars, each with a fixed metal disk, *e* and *e'*, (of any suitable size, and secured in any known manner to their respective pillar,) provided with pointed projecting pins *f* and *f'* around or near their periphery, as shown by the drawings. *g* and *g'* are two movable adjusting-screws, with hook ends, as seen in the drawings, running and supported through their respective pillars and disks, to regulate the tension of the fine metal wire *i* passing through the centre hole J of the magnet when this wire is attached to each hook end of the screws, so as to form the continuation of the main line through the magnet to its destination, without, however, touching the magnet. (See Figure 7; the black lines signify the centre hole J, and the red line the wire *i*.) When the pillars D and D' are placed in position for operation, the ends of their pointed pins on the disks are brought as near to the face or poles of the magnet as possible, without, however, permitting any contact with each other, so that the full attractive force or power of the magnet shall at all times exert its influence upon the points and disk of each pillar at the same time that a like action shall take place upon the central wire *i*, which, owing to its limited size or diameter compared with that of main lines, shall cause such a resistance to the "atmospheric electricity" passing upon it that a portion, if not all, shall be discharged at the points of the pins at the same time that the remainder, if any, shall be taken off of the wire by the magnet and transmitted to the ground by means of the supports *b b* and *b' b'* connected thereto before it shall reach an office or cable.

In Figure 2, A and A' are two distinct horse-shoe permanent magnets, single or compound, with their opposite poles facing each other, and secured to an ordinary insulating-board or frame (as shown in the drawings) by means of the metal binding-screws *a a a* and *a' a' a'* of each magnet. Between these magnets, facing their opposite poles, and without contact with the same, a piece of metal or stationary armature, B, of any size, shape, or thickness, provided with sharp projecting pins *c c c c* at each end, or a piece of metal wire of any size or thickness used as a substitute, with or without projecting pins, is secured to the same board or frame by the binding-screws *d* and *d'*. When these magnets are in position for operation, their poles are placed as close as possible to the ends of the projecting pins *c c c c* of the stationary armature B or wire, without, however, touching either, in order that they may at all times exert their attractive influence upon either, and cause any "atmospheric electricity" upon a main line reaching either to be repulsed by two poles of the magnets, while it is drawn or attracted by the other two and conveyed to the ground through the binding-screws *a a a* and *a' a' a'* and wires *f f f* or *f' f' f'*, connected thereto before reaching an office magnet or cable. Instead of two permanent magnets, two electro-magnets may be used with equal success, but in the latter case the insulated wire of the magnets should be protected from lightning and connected to an ordinary battery, as described in fig. 4.

ATHERFORCE

Figure 3 is a modification of fig. 2, inasmuch as A and A′ are two straight permanent magnets, (instead of horse-shoe magnets,) with teeth *b b b* and *b′ b′ b′* placed parallel to and with their opposite poles facing each other. These magnets are secured to an insulating-board or frame by their binding-screws *c c* and *c′ c′*, which also serve the purpose of connecting them with the ground by means of wires or metal bands *f* or *f′*, and their teeth *b b b* and *b′ b′ b′* are so arranged that they may be placed as near as possible, and between those of the additional plate D, marked *b″*, without contact, which plate is secured to its position between the magnets by the binding-screws *e* and *e′*. Instead of toothed magnets, the same straight permanent magnets may be used, but without teeth. In that case there should be two toothed stationary armatures D, (each secured to the board by binding-screws,) placed as near as possible, and facing the poles or each end of the magnets, without contact, so that the main line should continue its course to its destination by means of a metal wire, of any diameter, secured to the binding-screws of the armatures, and passed between and very close to the magnets without touching them.

Figure 4 is similar to fig. 1 in all its parts and connections with a telegraph line or a cable, excepting that in this device an electro-magnet, A, is used instead of a permanent magnet in connection with the metal binding-screws *c z*, to which the poles of an ordinary battery should be connected when in use, for the purpose of magnetizing the soft iron rod A, fig. 7, passing through the glass cylinder A, fig. 5, around which the helix is wrapped. *l* and *l′* represent the flanches of the glass cylinder or insulator, (see fig. 5,) which are to prevent the slipping or escape of the convolutions of the magnet wire from the cylinder. When an electro-magnet instead of a permanent magnet is applied or used as an "arrester," the glass cylinder is used for the better protection of the insulated wire forming the helix of the magnet, as it completely insulates the same from the destructive action of lightning when attracted by the magnetized rod and conveyed to the ground through the supports *b b* and *b′ b′* and their wires or bands, connected thereto in the usual manner.

As it is well known that gold, silver, and copper are among the very best of "lightning-conductors," I may, if I deem it desirable, "electroplate" the metal cores or magnets with either, for facilitating the conveyance of "atmospheric electricity" to the ground, and also for preventing the oxidation of the metals.

The connections of the herein-described devices with a main telegraph line or with a cable, &c., when arranged for operation are as follows: In figs. 1 or 4 the end of a main line, before connecting with an office magnet or with a cable, is first connected to one of the binding-screws of the pillars D or D′, continuing its course upon the fine metal wire *i* (attached to both pillars through the centre of the magnets) to its destination, while the supports *b b* and *b′ b′* are in metallic contact with the metal core or magnet, (see A, fig. 7,) for the purpose of conveying to the ground any atmospheric electricity that may be attracted by either pole of the magnet before reaching an office magnet or a cable. In fig. 2 the main line *m* is first connected to the binding-screw *d* of the stationary armature B, (or of the wire used as a substitute,) and from its other binding-screw *d′* continues its course upon the piece of fine wire *p*, forming part of a larger wire, (as shown in the drawings,) to its destination. This piece of fine wire *p*, in connection with a larger one, is used for the purpose of retarding the passage of the atmospheric electricity upon the armature, so as to enable the attractive power of the magnets to draw it off and convey it to the ground before it can overcome the resistance, caused by the limited size or diameter of the wire, and reach the office magnet or the cable. And the opposite poles of the magnets are made to face each other in order that the atmospheric electricity, (whether negative or positive, when passing on the armature B or its substitute,) shall be repulsed by two of them and drawn to the ground by the other two through the wires *f f f* and *f′ f′ f′* before it reaches an office magnet or a cable. In fig. 3 the connections with a main line or a cable and the ground are precisely the same as those in fig. 2.

Should it be found necessary to use any of the herein-described devices in connection with any telegraph line outside of an office, *i. e.*, to connect either to any part of a line between any two stations, it will only be necessary in such cases to cut the line in two and to connect each end of the wire to each binding-screw of the plate or substitute placed between the magnets, or to each pillar D and D′ of figs. 1 and 4 after having secured the arrester in a proper place.

I desire it to be fully understood that I do not confine myself to any particular size, shape, or power of the magnets, as they may be used single or compound; nor do I confine myself to the particular size or diameter of the wires *i* or *p*, when used as herein described, but, after having fully described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The application and use in connection with a paratonerre or lightning-arrester for telegraph wires, cables, &c., of one or more permanent magnets or electro-magnets, as and for the purposes herein described.

2. A lightning-arrester in which one or more permanent or electro-magnets are combined with the telegraph wire or cable and other parts of said arrester, in the manner shown and described, or in any other form of mechanical arrangement substantially equivalent to the same, as set forth.

ARTHUR BARBARIN.

Witnesses:

RUFUS R. RHODES,

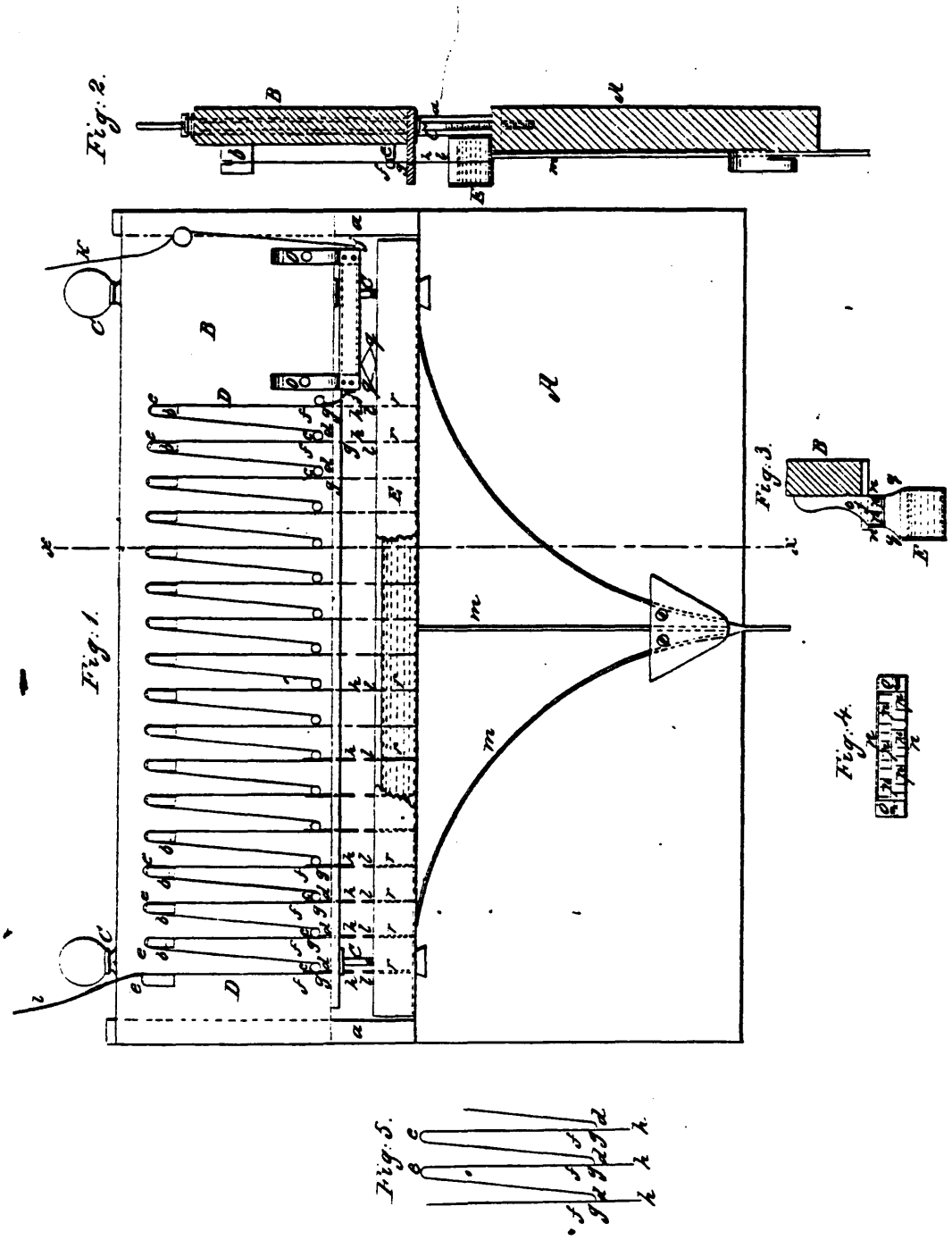
H. N. JENKINS.

AETHERFORCE

J. N. GAMEWELL.

Lightning Arrester.

No. 13,389. Patented Aug. 7, 1855.



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UNITED STATES PATENT OFFICE.

JOHN N. GAMEWELL, OF CAMDEN, SOUTH CAROLINA.

IMPROVEMENT IN APPARATUS FOR DISCHARGING ATMOSPHERIC ELECTRICITY FROM TELEGRAPH-WIRES.

Specification forming part of Letters Patent No. **13,389**, dated August 7, 1855.

To all whom it may concern:

Be it known that I, JOHN N. GAMEWELL, of Camden, in the district of Kershaw and State of South Carolina, have invented a new and useful Instrument for Relieving the Wires of the Electric Telegraph of Atmospheric Electricity; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a front view of the instrument. Fig. 2 is a vertical transverse section of the same in the line *x x* of Fig. 1. Fig. 3 is a transverse section, and Fig. 4 a top view, of parts of the instrument. Fig. 5 is a detached view of a part of the train of wire through which the galvanic current passes.

Similar letters of reference indicate corresponding parts in the several figures.

This invention consists in an instrument which is intended to connect the main wire of the telegraph with the receiving-magnet at every station, for the purpose of transmitting only the galvanic or writing current and discharging into the earth, before it can arrive at the magnet, all atmospheric electricity with which the wires become surcharged when the atmosphere is in a highly electrical state, thereby obviating all danger of injury to the magnets or other apparatus, and enabling the telegraph to be operated during the severest thunder-storms.

The theory upon which this instrument is constructed is based mainly upon the established principle that atmospheric electricity will leap from one conductor to another, but that a galvanic current such as used in the ordinary working of the telegraph will not pass through the smallest space without a continuous conductor. Its construction and operation are as follows:

A B are two boards placed edgewise one above the other, and made adjustable at different distances apart by screws C C, and kept in proper longitudinal relation to each other by dovetail bars *a a*, which are attached to A and fit in dovetail grooves in the ends of B. To the face of the upper board, B, are secured number of studs *b b c c*, of ivory or other insulating material, to support a train of wire, D D, which forms part of the main circuit and passes upward and downward in a serpentine form, bending rather suddenly, as shown in Figs. 1 and 5. This train of wire is composed of long pieces *d e f* of some inferior conductor—as, for instance, platina or iron (represented in blue color)—and short pieces *g* of superior conductor—as, for instance, gold, silver, or copper (represented in red color)—in alternate succession, each long piece *d e f* of inferior conductor starting at the lower bend, close to one of the lower studs, *c c*, passing over one of the upper studs, *b b*, and then passing downward, to be soldered or otherwise connected with the end *d* of the next similar piece by means of one of the shorter pieces *g g* of superior conductor, which, after making the connection between *f* and *d*, descends to terminate in a point, *h*, below the bottom of the upper board, B. The reason for this extension to a point is that points, sharp angles, &c., are favorable to the discharge of electricity. The lengths of wire composing this train D D diminish gradually in size from one end to the other, the first being of about one-tenth of an inch and the last about one two-hundredths of an inch in thickness. The train is connected at the thickest end with the usual main wire, *i*, which enters the office, and at the thinnest end with one end of a thin sheet of platina, *j*, from whose opposite end a fine platina wire, *k*, leads to the magnet.

In close proximity to the points *h h* are the points *l l* of a series of superior conducting-wires, *r r*, which are soldered or otherwise attached to the bottom of a copper trough, E, which rests upon the lower board, A. These points are for the purpose of receiving discharges of atmospheric electricity from *h h*, as will be hereinafter more fully explained.

The trough, which is shown with its front partly broken away in Fig. 1, contains water to moisten the atmosphere in the neighborhood of the points *h l*, to cause the electricity to be readily conducted from *h* to *l*, and to prevent the fusion of the points; and to the bottom of the said trough are attached one or more wires, *m*, of copper, to enter the ground.

On opposite sides of and at a short distance from the platina plate *j* are placed two copper plates, *n n*, which are insulated by the brackets O O, which carry them and the platina plate and attach them to the board B. These copper plates *n n* are studded all over their inner faces with points *p p*, of superior conducting-metal, which are in close proximity to the platina plate *j*, (see section Fig. 3 and plan Fig. 4,) and they are connected with the trough E by copper wires *q q*, which are of such form

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that they will yield readily when the boards are adjusted by the screws C C.

To facilitate the explanation of the operation of the instrument, the distinction of color before referred to between the superior and inferior conductors is observed throughout. The sheet of platina *j* and the wire *k*, which form parts of the writing-circuit, are colored blue, and the points *l l* and *p p*, the trough E, the plates *n n*, and the wires *q q* and *m m*, which discharge the atmospheric electricity, are colored red.

To proceed with the explanation of the operation: The wire *i* brings into the office the galvanic or writing current, and also any atmospheric current with which it may have become surcharged, and the whole charge, consisting of the atmospheric and galvanic currents, is received by the first length of inferior conducting-wire in the train D D; but in passing from the first to the second length *d e f* of inferior conducting-wire it has to pass for a short distance along the superior conducting-wire *g*, which, by reason of its extension in the form of a point which is in proximity to a point, *l*, in communication with the ground, is caused to discharge a portion of the atmospheric electricity, which is received by *l* and conducted by the trough E and wires *m* into the ground. The charge, in passing from the second to the third length *d e f* of inferior conducting-wire through the second length of superior conducting-wire *g*, is caused in the same way to make a second discharge from the second point *h* to the second point *l*, and the same effect is repeated until the whole of the atmospheric current is discharged and the galvanic current only remains in the wire; or, if any of the atmospheric current still remains when it reaches the platina plate *j*, it is received upon the points *p p* and conducted by the plates *n n* and wires *q q* to the trough E, from which it passes by the wire *m* into the ground.

The reason for diminishing the size of the train of wire D D is that the current, though diminishing in quantity, may be continually obstructed, and greater facility thereby afforded for the discharges at the points *l l*.

The number of discharging-points *h h* employed is by no means arbitrary. About fifteen or twenty may be successfully employed.

The length of wire between the discharging-points *h h* will depend upon the distance of the points *h h* from the points *l l*.

The resistance offered to the passage of the atmospheric electricity along the inferior conductors from one discharging-point *h* to another *h* should be greater than that presented by the thin plate of air between the points *h h* and *l l*. I usually make these lengths of inferior conductor from four to six inches long; but they will depend, as stated before, upon the distance between the points *h h* and *l l*. If adjusted to a proximity of one-twentieth of an inch and the reduction of capacity be one fourth or one-third, four inches will be sufficient.

The short lengths *g* of wire I make of silver of a total length of three-quarters of an inch, the part forming the connection between the lengths of platina being one-quarter and the part extended to form the point *h* being half an inch.

The trough E may contain a depth of water of about three-quarters of an inch; but this is not material, as it only requires to be sufficient to moisten the surrounding air.

The wires *r r* may be all of silver, or the submerged part of copper and the pointed parts *l l* (which should barely project above the water) of silver.

The only adjustment which the instrument requires is to set the points *h h* and *l l* in the closest proximity without touching during a highly electrical state of the atmosphere, and to move them farther apart during an ordinary state thereof; but even this adjustment may not be nessary, as the present knowledge of electrical phenomena leads to the belief that when the points are in close proximity without touching there is no danger of the discharge of the galvanic current.

At the terminal stations of the telegraph-line only one of these instruments is required, as the current only enters in one direction; but at the intermediate stations two are necessary—viz., one on each side of the receiving-magnet.

The practical utility of and demand for such an instrument may, in some measure, be estimated by the fact that the loss of a single telegraph-line in the United States during the last year by interruptions in its operation caused by the prevalence of electricity in the atmosphere was computed at a sum of forty thousand dollars. The successful operation of the instrument as a magnet-protector has been proved beyond doubt.

I do not claim the use of discharging-points connected with the ground to carry off atmospheric electricity.

What I claim as my invention, and desire to secure by Letters Patent, is—

The method of obstructing the passage of atmospheric electricity along the line from one discharging-point to another, or their equivalents provided for a similar purpose, by reducing the capacity of the conductor forming said line at and immediately after its junction with said discharging-points *h h*, whether that reduction consists in the employment of an inferior conducting material or in reducing the dimensions of the conductor, as herein set forth, or any other equivalent method of reducing the conducting capacity at those parts of the line, thereby forcing the discharge of the atmospheric electricity from the points *h h*, as herein described.

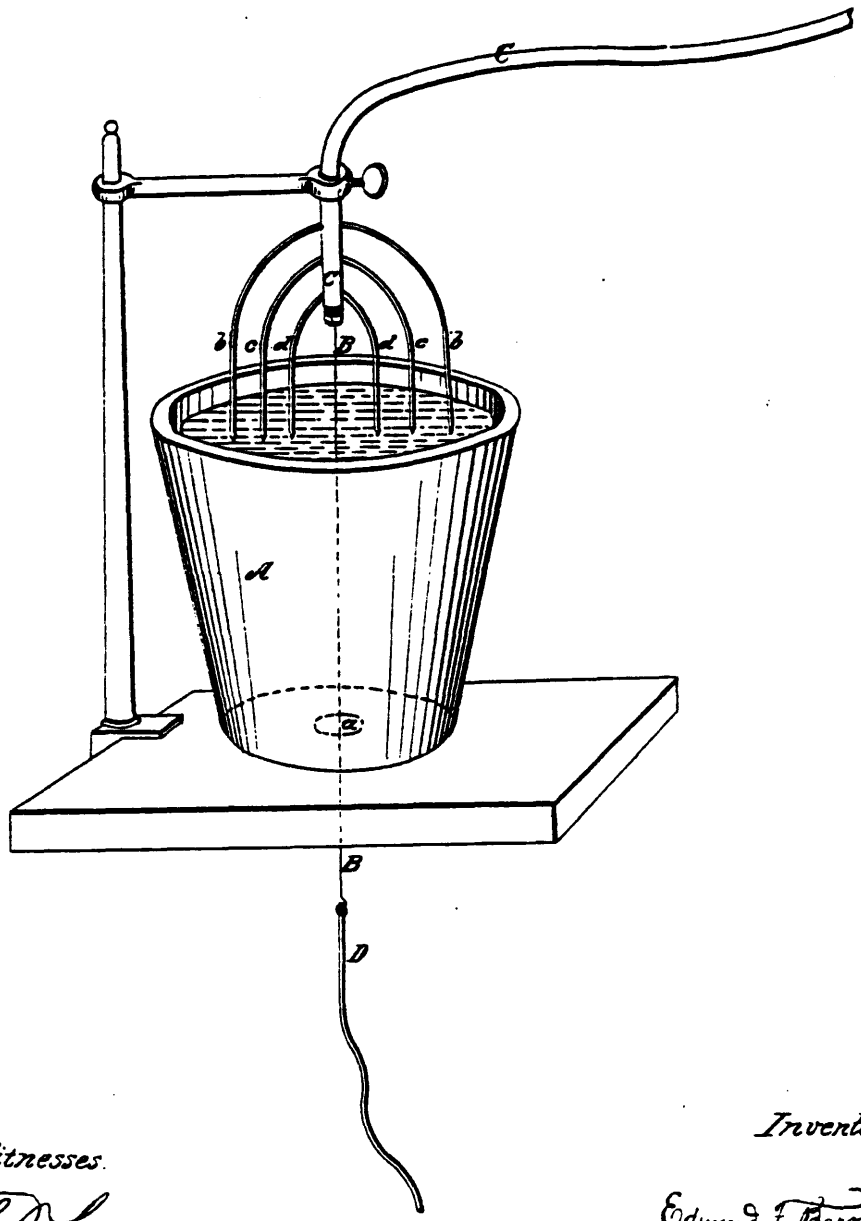
Witnesses: JOHN N. GAMEWELL.
S. H. WALES,
I. G. MASON.

AETHERFORCE

E. F. BARNES.

Lightning Arrester.

No. 25,939. Patented Nov. 1, 1859.



Witnesses.

S. D. Law

Alfred M. Intore

Inventor

Edmund F. Barnes

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

E. F. BARNES, OF BROOKLYN, NEW YORK.

IMPROVED METHOD OF PROTECTING TELEGRAPHIC INSTRUMENTS AGAINST ATMOSPHERIC ELECTRICITY.

Specification forming part of Letters Patent No. **25,939**, dated November 1, 1859.

To all whom it may concern:

Be it known that I, EDMUND F. BARNES, of the city of Brooklyn, county of Kings, and State of New York, have invented and applied to use certain new and useful improvements in apparatus to be used in connection with telegraphic machinery or instruments for the purpose of preventing the effect of undue quantities of atmospheric electricity, and which I call an "Atmospheric-Electricity Discharger;" and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, and making a part of this specification.

The nature of my invention consists in interposing between the main wire of a telegraph-line and the telegraphic instrument an arrangement or combination of parts which shall disperse any undue quantity of atmospheric electricity before it reaches the telegraphic instrument, and thus prevent its usual effects in interfering with the free action of the instrument. Such arrangement or combination and its action is as follows:

A is a vessel, of glass, earthenware, or any material which is a non-conductor of electricity, and having through its bottom a small hole, *a*. Through such hole passes a small platinum wire, B, and it is then closed by any substance which will render it close, so that the vessel will hold liquid. One end of such platinum wire is attached to the wire C of the main line, and the other end is attached to a wire, D, which leads to one of the poles of the "mutator," so called, (when such instrument is used,) or to the resident magnet in a telegraphic instrument.

From the end of the main wire C project points or short wires *b c d*, which extend into the vessel A and below the surface of the fluid contained in it. This fluid is of such a character (as a solution of one part of sulphuric acid and twelve parts of water) that while it is a conductor of electricity its conductibility is less than that of the platinum wire which passes through it connecting the main wire and the mutator or instrument. Such platinum wire is also of such a size that it will allow the proper and easy passage of all necessary electricity to operate the instrument.

So long as the main wire is charged with only the voltaic current or the electricity produced by the battery, the whole passes through the platinum wire to the instrument, because the conductibility of such wire is greater than that of the fluid in the vessel into which the points *b c d* enter, and none of the electricity will therefore pass from off such points. Whenever the main wire becomes additionally charged by a superabundance of atmospheric electricity the intensity of which is higher, the platinum wire will, in fact, continue to conduct only the voltaic current, or but little in addition thereto, and such atmospheric electricity will pass from the main wire by means of the points *b c d* in the fluid in A, that being the next best conductor, near the platinum wire, and will be dissipated again into the atmosphere. The effect of the whole arrangement is therefore to dissipate the atmospheric electricity before it reaches the telegraphic instrument, the operation of which is not thus interfered with, but it works as well, or nearly as well, when atmospheric electricity is excited as when inert.

The benefit and advantage of my invention is therefore to provide and have in constant readiness upon and in connection with any telegraphic line and the instruments used thereon a certain means of dissipating any atmospheric electricity, which else would seriously interfere with their use and action; but on the other hand such arrangement does not in any respect interfere with the proper action of such instruments under ordinary circumstances, and have any telegraphic line furnished with this invention can be worked during times when the equilibrium of the atmospheric electricity is disturbed as when not.

The vessel A may be filled with any slightly-acidulated fluid instead of the fluid mixed exactly as above described, or may be filled with pure water, though in such case such vessel will require to be considerably larger.

Silver or copper wire or a wire of any good conductibility may be used in place of the platinum wire; but the latter is much preferable, as it is a sufficient conductor and does not fuse at any ordinary temperature.

By so discharging the atmospheric electricity all danger is prevented of its melting the wire in the coils of the magnet when its volume is

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large, or, when smaller, of destroying the adjustability of any magnet as at present used.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The application and use, in a telegraphic line or in connection with telegraphic instruments, of a vessel, A, containing acidulated water or fluid, as described, and having a platinum or other metallic wire, B, of better conductibility than the contents of such vessel, passing through such vessel and connecting by one end with the main wire and by the other with the telegraphic machine, the whole arranged substantially as and for the purposes set forth.

2. In combination or connection with such vessel of fluid A and wire B, the arrangement of the metallic points *b c d* on the wire of the main line and extending into the fluid in A, substantially as and for the purpose set forth.

EDMUND F. BARNES.

Witnesses:

S. D. LAW,

ALFRED MCINTIRE.

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G. A. STEARNS.

Lightning Arrester.

No. 43,265. Patented June 21, 1864.

Fig. 1.

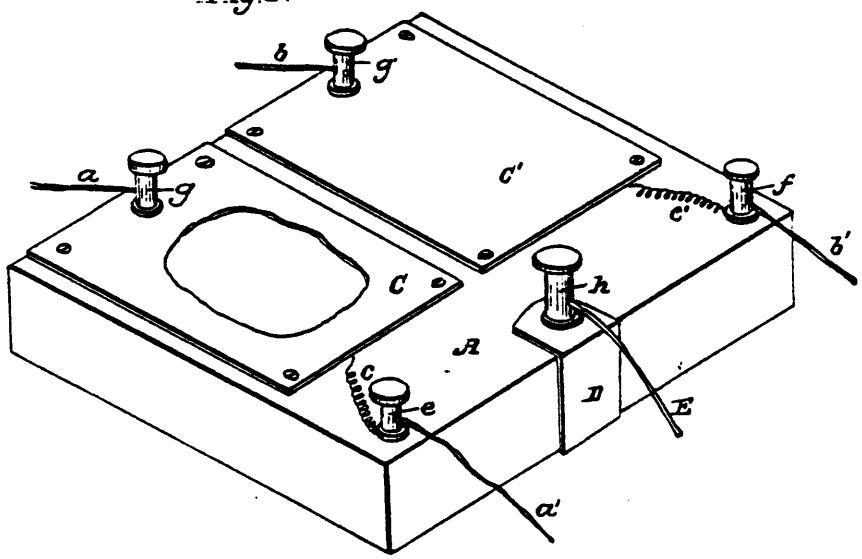


Fig. 3.

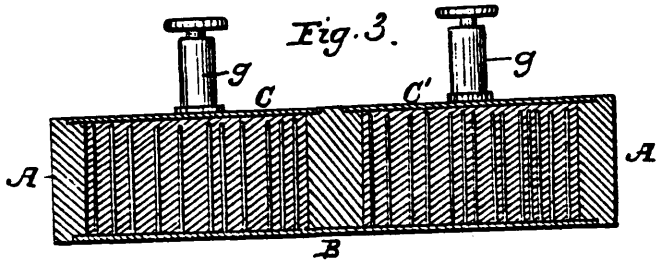
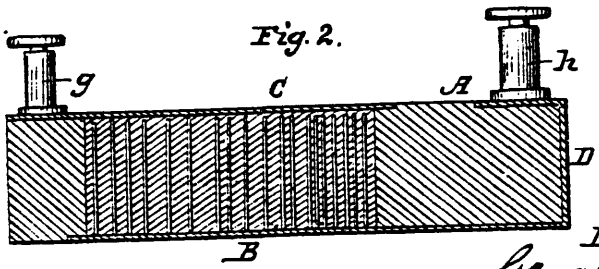


Fig. 2.



Witnesses:
John L. Brooke
H. King

Inventor
George A. Stearns
by Robbins & Burr
his attorneys

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

GEORGE A. STEARNS, OF ROCHESTER, NEW YORK, ASSIGNOR TO HIMSELF AND ELIJAH VALENTINE, OF MILWAUKEE, WISCONSIN.

IMPROVEMENT IN LIGHTNING-ARRESTERS FOR TELEGRAPHS.

Specification forming part of Letters Patent No. **43,265**, dated June 21, 1864.

To all whom it may concern:

Be it known that I, GEORGE A. STEARNS, of Rochester, in the county of Monroe and State of New York, have invented a new and Improved Paratonnerre or Lightning-Arrester, for the protection of telegrapic apparatus from injury and derangement by atmospheric electricity; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, forming a part of this specification, in which—

Figure 1 is a perspective view of my improved apparatus; Fig. 2, a section of the same in the line *x x* of Fig. 1, and Fig. 3 a section in the line *y y* of Fig. 1.

Similar letters indicate like parts in the several figures.

It is well known to telegraph operators and others familiar with the working of the electric telegraph that the operation of a line is frequently impeded, and even prevented, by reason of the wires becoming surcharged with atmosheric electricity, in addition to the current of voltaic electricity by means of which the signals are transmitted over the wires. Serious damage to the telegraphic apparatus, as well as sometimes to the operators themselves, frequently results from this cause, as also great inconvenience to the public. These inconveniences are experienced particularly during the continuance of a lightning-storm, although they also arise during damp weather. Many efforts have been made to obviate these evils by providing an attachment to the ordinary apparatus of a telegraph-office, by means of which the atmospheric electricity may be discharged from the wires without impeding the due passage and operation of the voltaic current; but none of the paratonnerres that have hitherto been invented are perfectly reliable and efficient in their operation, inasmuch as none of them afford a continuous conductor for the passage of the atmospheric electricity from the line-wires to the ground in a separate current from that of the voltaic electricity.

My present invention has for its object the remedying of this defect, and is based upon the discovery that certain substances—such as charcoal, powdered sulphur, powdered glass, amber, and their equivalents—are good conductors of atmospheric electricity, but are practically non-conductors of voltaic electricity.

The accompanying drawings represent a practical application of this discovery to the purpose indicated.

A represents a base-block, of wood, gutta-percha, or other suitable non-conducting substance, through which two large openings are cut, as represented in Fig. 3. To the under side of this block is secured a metallic plate, B, of such size as to completely cover both of the openings through the block. Upon the upper side of the block are secured the two metallic plates C C′, each covering one of the through-openings, and which plates C and C′ are made to form part of the line-circuit of the telegraph.

Between the plates B C and B C′ is placed the charcoal, powdered glass, amber, or other equivalent substance which is a good conductor of atmospheric electricity and a non-conductor of voltaic electricity. This substance must be in immediate contact with both the upper plates, C C′, and the lower plate, B, and when charcoal is employed as a conductor I find it preferable to use it in a solid form and to place it with the grain as near as may be perpendicular to the metallic plates.

The paratonnerre may be placed either inside or outside of the telegraph-office. It is provided with suitable binding-posts for the attachment of the various wires. The under plate, B, may be provided with a tongue, D, which passes around one edge of the base-block A, and is secured to the upper surface thereof by means of the binding-post *h*, with which is connected the ground-wire E, for discharging the atmospheric electricity into the earth.

The ground-connection may be established in any other suitable manner.

In Fig. 1, *a* represents one of the main-line wires, which is connected with the metallic plate C by means of the binding-post *e*. The plate C is thus made to form part of the line-circuit, and transmits the voltaic current by means of the small platinum wire *c*, binding-post *e*, and relay-wire *a′* to the registering apparatus.

b represents another line-wire between which and the registering apparatus a metallic connection is established by means of the binding-posts *g′* and *f*, metallic plate C′, platinum wire *c*, and relay-wire *b′*. The platinum wires *c c′*,

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are of such a size as to conduct no greater current than will the relay-wires *a'* and *b'*.

The operation of my paratonnerre is obvious and very simple. The atmospheric electricity, being conveyed by the line-wires to the plate C or C', is conducted by the charcoal, or other similar substance to the plate B, whence it is discharged into the earth by means of the ground-wire E, and at the same time the voltaic current may be in full and uninterrupted operation.

In order to make my improved lightning-arrester more efficient in discharging violent currents of atmospheric electricity, such as are present during a severe lightning storm, I insert fine metallic wires in the charcoal, or other equivalent substance, in a perpendicular position relative to the plates B and C, and so that they are in contact with one of these plates and nearly so with the other.

As this my improved paratonnerre arrests not only the violent currents, but even the slightest currents of atmospheric electricity, it is plain that its use will obviate the necessity of that frequent change of adjustment which is a source of so much annoyance and trouble to the operator, and which, to be made intelligently, requires long practical experience. Thus the duty of the operator is much simplified.

Having thus fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. Establishing a communication between the line-circuit of an electric telegraph and the earth by the use of charcoal, powdered glass, powdered amber, powdered sulphur, or other equivalent substance, when brought into contact with such line-circuit by means of a suitable apparatus, for the purpose of discharging from the wire all atmospheric electricity before it can be communicated to the registering apparatus, substantially in the manner herein represented and described.

2. When charcoal, powdered glass, powdered amber, powdered sulphur, or other equivalent substance is employed for the purpose above indicated, and in substantially the manner herein described, inserting therein metallic rods or wires, in the manner and for the purpose herein represented and described.

The above specification of my improvement to prevent atmospheric electricity from interfering with the workings of the telegraph signed by me this 4th day of February, A. D. 1864.

GEO. A. STEARNS.

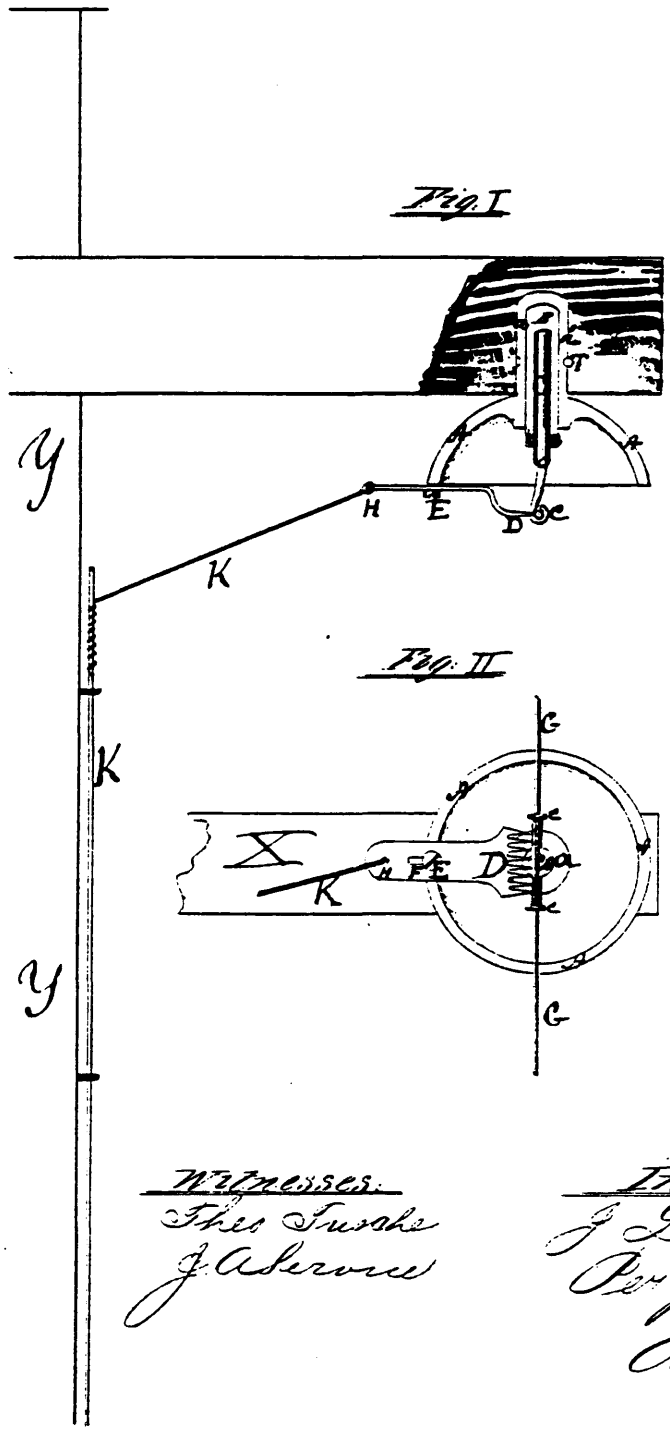
In presence of—
HARRAH J. REYNOLDS,
M. B. COMFORT.

ÆTHERFORCE

A. L. FINN.

Telegraph Insulator.

No. 75,889. Patented March 24, 1868.



Witnesses:
Theo Tusche
J. A. Service

Inventor:
J. L. Finn
Per Munn & Co
Attorneys

ÆTHERFORCE

United States Patent Office.

J. L. FINN, OF ELYRIA, OHIO.

Letters Patent No. 75,889, *dated March* 24, 1868.

IMPROVEMENT IN TELEGRAPH-INSULATORS.

The Schedule referred to in these Letters Patent and making part of the same.

TO ALL WHOM IT MAY CONCERN:

Be it known that I, J. L. FINN, of Elyria, in the county of Lorain, and State of Ohio, have invented a new and useful Improvement in Telegraph-Insulators; and I do hereby declare that the following is a full, clear, and exact description thereof, which will enable others skilled in the art to make and use the same, reference being had to the accompanying drawings, forming part of this specification.

This invention consists of an improved telegraph-insulator and lightning-arrester; and its objects are to provide a more effectual mode of insulating telegraph-wires, and to collect and arrest the free electricity pervading the wires, and convey it harmlessly into the ground. It can also be applied in other cases in which the presence of free electricity interferes with the use of the electrometer or galvanometer. In the accompanying drawings—

Figure 1 is a vertical section of my improved insulator, and

Figure 2 is a bottom plan thereof.

The same letters apply to the same parts in both drawings.

The insulator consists of a dome or bell-shaped shell, A, of cast iron, or other suitable material, carrying a hollow shank, *a*, inserted in the arm or bearer X, attached to the telegraph-pole Y, and in which shank is fitted an insulator, B, of glass, china, porcelain, or other non-conducting substance, glass being preferred. The shank *a* is secured in the arm X by one or more pins T passing through the arm and into a slot or groove in the exterior surface of the shank made to receive it, or it may be secured in any other suitable manner. The arm X is attached to the telegraph-pole Y in any suitable manner, so that the mouth of the bell hangs down, to preserve the apparatus from the weather, and from watery connection with the earth. An iron fork, C, bearing the telegraph-wire in its prongs *c c*, hooked for that purpose, is held by its shank, C, in the glass insulator B, and may be secured with cement, if desired. A toothed conductor, D, made of sheet copper, or other good conducting substance, is secured in place by a screw, E, passing through a slot, F, in the shank or shaft H of the toothed conductor, into the rim or base of the shell A, and is adjusted by means of the screw E and slot F to within one-twentieth of an inch from the telegraph-wire, and I prefer that it shall approach the wire between the prongs of the iron fork *c c*. A ground or conducting-wire, K, attached to and electrically connected with the shaft H of the toothed conductor D, is led to the telegraph-pole Y, and thence into the ground. And by this arrangement the free electricity which, during storms, or an electric condition of the atmosphere, or from any other cause, may pervade the wires, often seriously impeding the working of and sometimes destroying the telegraph, will be collected and arrested by the toothed conductor, and carried harmlessly away.

The results obtained by the electrometer and galvanometer are often rendered unreliable through the presence of free electricity, and my invention can be readily adapted to remove this cause of error.

I do not confine myself to the use of any particular form of arrester, but prefer the form here shown.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The combination and arrangement of the bell-shaped shell A, forked shank C, the adjustable toothed conductor D, and conducting-wire K, substantially as described for the purpose specified.

2. Securing the shank *a* to the bearer X, by means of the tangential pins T, passing through a groove in the side of the said shank, substantially as described for the purpose specified.

J. L. FINN.

Witnesses:

I. R. FINN,

H. W. BLISS.

AETHERFORCE

HERMAN MELVILLE WROTE AN EXTRAORDINARY ACCOUNT OF LIGHTNING STORMS, LIGHTNING RODS, AND A PECULIAR BREED OF SALESMAN...

THE LIGHTNING-ROD MAN

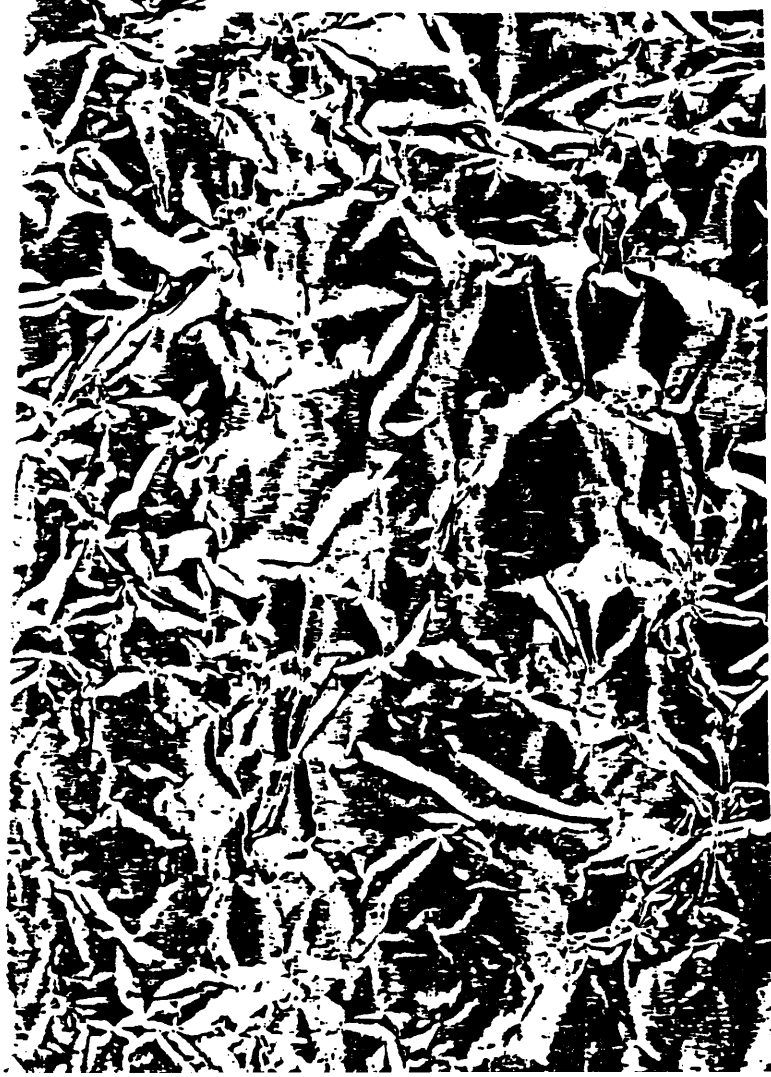
WHAT grand irregular thunder, thought I, standing on my hearth-stone among the Acroceraunian hills, as the scattered bolts boomed overhead, and crashed down among the valleys, every bolt followed by zigzag irradiations, and swift slants of sharp rain, which audibly rang, like a charge of spear-points, on my low shingled roof. I suppose, though, that the mountains hereabouts break and churn up the thunder, so that it is far more glorious here than on the plain. Hark!—someone at the door. Who is this that chooses a time of thunder for making calls? And why don't he, man-fashion, use the knocker, instead of making that doleful undertaker's clatter with his fist against the hollow panel? But let him in. Ah, here he comes. 'Good day, sir': an entire stranger. 'Pray be seated.' What is that strange-looking walking-stick he carries? 'A fine thunder-storm, sir.'

'Fine?—Awful!'

'You are wet. Stand here on the hearth before the fire.'

'Not for worlds!'

The stranger still stood in the exact middle of the cottage, where he had first planted himself. His singularity impelled a closer scrutiny. A lean, gloomy figure. Hair dark and lank, mattedly streaked over his brow. His sunken pitfalls of eyes were ringed by indigo halos, and played with an innocuous sort of lightning: the gleam without the bolt. The whole man was dripping.



He stood in a puddle on the bare oak floor: his strange walking-stick vertically resting at his side.

It was a polished copper rod, four feet long, lengthwise attached to a neat wooden staff by insertion into two balls of greenish glass, ringed with copper bands. The metal rod terminated at the top tripodwise, in three keen tines, brightly gilt. He held the thing by the wooden part alone.

'Sir,' said I, bowing politely, 'have I the honour of a visit from that illustrious god, Jupiter Tonans? So stood he in the Greek statue of old, grasping the lightning-bolt. If you be he, or his viceroy, I have to thank you for this noble storm you have brewed among our mountains. Listen: That was a glorious peal. Ah, to a lover of the majestic, it is a good thing to have the Thunderer himself in one's cottage. The thunder grows finer for that. But pray be seated. This old rush-bottomed arm-chair, I grant, is a poor substitute for your evergreen throne on Olympus; but, condescend to be seated.'

While I thus pleasantly spoke, the stranger eyed me, half in wonder, and half in a strange sort of horror; but did not move a foot.

'Do, sir, be seated; you need to be dried ere going forth again.'

I planted the chair invitingly on the broad hearth, where a little fire had been kindled that afternoon to dissipate the dampness, not the cold; for it was early in the month of September.

But without heeding my solicitation, and still standing in the middle of the floor, the stranger gazed at me portentously and spoke.

'Sir,' said he, 'excuse me; but instead of my accepting your invitation to be seated on the hearth there, I solemnly warn *you*, that you had best accept *mine*,

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and stand with me in the middle of the room. Good heavens!' he cried, starting—'there is another of those awful crashes. I warn you, sir, quit the hearth.'

'Mr. Jupiter Tonans,' said I, quietly rolling my body on the stone, 'I stand very well here.'

'Are you so horridly ignorant, then,' he cried, 'as not to know, that by far the most dangerous part of a house, during such a terrific tempest as this, is the fireplace?'

'Nay, I did not know that,' involuntarily stepping upon the first board next to the stone.

The stranger now assumed such an unpleasant air of successful admonition, that—quite involuntarily again—I stepped back upon the hearth, and threw myself into the erectest, proudest posture I could command. But I said nothing.

'For heaven's sake,' he cried, with a strange mixture of alarm and intimidation—'for heaven's sake, get off the hearth! Know you not, that the heated air and soot are conductors;—to say nothing of those immense iron fire-dogs? Quit the spot—I conjure—I command you.'

'Mr. Jupiter Tonans, I am not accustomed to be commanded in my own house.'

'Call me not by that pagan name. You are profane in this time of terror.'

'Sir, will you be so good as to tell me your business? If you seek shelter from the storm, you are welcome, so long as you be civil; but if you come on business, open it forthwith. Who are you?'

'I am a dealer in lightning-rods,' said the stranger, softening his tone; 'my special business is—— Merciful heaven! what a crash!—Have you ever been struck—your premises, I mean? No? It's best to be provided';—significantly rattling his metallic staff on the

floor;—'by nature, there are no castles in thunderstorms; yet, say but the word, and of this cottage I can make a Gibraltar by a few waves of this wand. Hark, what Himalayas of concussions!'

'You interrupted yourself; your special business you were about to speak of.'

'My special business is to travel the country for orders for lightning-rods. This is my specimen rod,' tapping his staff; 'I have the best of references'—fumbling in his pockets. 'In Criggan last month, I put up three-and-twenty rods on only five buildings.'

'Let me see. Was it not at Criggan last week, about midnight on Saturday, that the steeple, the big elm, and the assembly-room cupola were struck? Any of your rods there?'

'Not on the tree and cupola, but the steeple.'

'Of what use is your rod, then?'

'Of life-and-death use. But my workman was heedless. In fitting the rod at top to the steeple, he allowed a part of the metal to graze the tin sheeting. Hence the accident. Not my fault, but his. Hark!'

'Never mind. That clap burst quite loud enough to be heard without finger-pointing. Did you hear of the event at Montreal last year? A servant girl struck at her bedside with a rosary in her hand; the beads being metal. Does your beat extend into the Canadas?'

'No. And I hear that there, iron rods only are in use. They should have *mine*, which are copper. Iron is easily fused. Then they draw out the rod so slender, that it has not body enough to conduct the full electric current. The metal melts; the building is destroyed. My copper rods never act so. Those Canadians are fools. Some of them knob the rod at the top, which risks a deadly explosion, instead of imperceptibly carry-

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ing down the current into the earth, as this sort of rod does. *Mine* is the only true rod. Look at it. Only one dollar a foot.'

'This abuse of your own calling in another might make one distrustful with respect to yourself.'

'Hark! The thunder becomes less muttering. It is nearing us, and nearing the earth, too. Hark! One crammed crash! All the vibrations made one by nearness. Another flash. Hold!'

'What do you?' I said, seeing him now, instantaneously relinquishing his staff, lean intently forward toward the window, with his right fore and middle fingers on his left wrist.

But ere the words had well escaped me, another exclamation escaped him.

'Crash! only three pulses—less than a third of a mile off—yonder, somewhere in that wood. I passed three stricken oaks there, ripped out new and glittering. The oak draws lightning more than other timber, having iron in solution in its sap. Your floor here seems oak.'

'Heart-of-oak. From the peculiar time of your call upon me, I suppose you purposely select stormy weather for your journeys. When the thunder is roaring, you deem it an hour peculiarly favourable for producing impressions favourable to your trade.'

'Hark!—Awful!'

'For one who would arm others with fearlessness, you seem unbeseemingly timorous yourself. Common men choose fair weather for their travels; you choose thunder-storms; and yet——'

'That I travel in thunder-storms, I grant; but not without particular precautions, such as only a lightning-rod man may know. Hark! Quick—look at my specimen rod. Only one dollar a foot.'

'A very fine rod, I dare say. But what are these particular precautions of yours? Yet first let me close yonder shutters; the slanting rain is beating through the sash. I will bar up.'

'Are you mad? Know you not that yon iron bar is a swift conductor? Desist.'

'I will simply close the shutters, then, and call my boy to bring me a wooden bar. Pray, touch the bell-pull there.'

'Are you frantic? That bell-wire might blast you. Never touch bell-wire in a thunder-storm, nor ring a bell of any sort.'

'Nor those in belfries? Pray, will you tell me where and how one may be safe in a time like this? Is there any part of my house I may touch with hopes of my life?'

'There *is*; but not where you now stand. Come away from the wall. The current will sometimes run down a wall, and—a man being a better conductor than a wall—it would leave the wall and run into him. Swoop! *That* must have fallen very nigh. That must have been globular lightning.'

'Very probably. Tell me at once, which is, in your opinion, the safest part of this house?'

'This room, and this one spot in it where I stand. Come hither.'

'The reasons first.'

'Hark!—after the flash the gust—the sashes shiver—the house, the house!—Come hither to me!'

'The reasons, if you please.'

'Come hither to me!'

'Thank you again, I think I will try my old stand—the hearth. And now, Mr. Lightning-rod man, in the pauses of the thunder, be so good as to tell me your reasons for esteeming this one room of the house the

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safest, and your own one standpoint there the safest spot in it.'

There was now a little cessation of the storm for a while. The Lightning-rod man seemed relieved, and replied:

'Your house is a one-storied house, with an attic and a cellar; this room is between. Hence its comparative safety. Because lightning sometimes passes from the clouds to the earth, and sometimes from the earth to the clouds. Do you comprehend?—and I choose the middle of the room, because, if the lightning should strike the house at all, it would come down the chimney or walls; so, obviously, the further you are from them, the better. Come hither to me, now.'

'Presently. Something you just said, instead of alarming me, has strangely inspired confidence.'

'What have I said?'

'You said that sometimes lightning flashes from the earth to the clouds.'

'Ay, the returning-stroke, as it is called; when the earth, being overcharged with the fluid, flashes its surplus upward.'

'The returning-stroke; that is, from earth to sky. Better and better. But come here on the hearth and dry yourself.'

'I am better here, and better wet.'

'How?'

'It is the safest thing you can do—Hark, again!—to get yourself thoroughly drenched in a thunder-storm. Wet clothes are better conductors than the body; and so, if the lightning strike, it might pass down the wet clothes without touching the body. The storm deepens again. Have you a rug in the house? Rugs are non-conductors. Get one, that I may stand on it here, and

you, too. The skies blacken—it is dusk at noon. Hark!—the rug, the rug!'

I gave him one; while the hooded mountains seemed closing and tumbling into the cottage.

'And now, since our being dumb will not help us,' said I, resuming my place, 'let me hear your precautions in travelling during thunder-storms.'

'Wait till this one is past.'

'Nay, proceed with the precautions. You stand in the safest possible place according to your own account. Go on.'

'Briefly, then. I avoid pine-trees, high houses, lonely barns, upland pastures, running water, flocks of cattle and sheep, a crowd of men. If I travel on foot—as to-day—I do not walk fast; if in my buggy, I touch not its back or sides; if on horseback, I dismount and lead the horse. But of all things, I avoid tall men.'

'Do I dream? Man avoid man? and in danger-time, too.'

'Tall men in a thunder-storm I avoid. Are you so grossly ignorant as not to know, that the height of a six-footer is sufficient to discharge an electric cloud upon him? Are not lonely Kentuckians, ploughing, smit in the unfinished furrow? Nay, if the six-footer stand by running water, the cloud will sometimes *select* him as its conductor to that running water. Hark! Sure, yon black pinnacle is split. Yes, a man is a good conductor. The lightning goes through and through a man, but only peels a tree. But, sir, you have kept me so long answering your questions that I have not yet come to business. Will you order one of my rods? Look at this specimen one. See: it is of the best of copper. Copper's the best conductor. Your house is low; but being upon the mountains, that lowness does not one whit depress it. You mountaineers are most

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exposed. In mountainous countries the lightning-rod man should have most business. Look at the specimen, sir. One rod will answer for a house so small as this. Look over these recommendations. Only one rod, sir; cost, only twenty dollars. Hark! There go all the granite Taconics and Hoosics dashed together like pebbles. By the sound, that must have struck something. An elevation of five feet above the house will protect twenty feet radius all about the rod. Only twenty dollars, sir—a dollar a foot. Hark!—Dreadful!—Will you order? Will you buy? Shall I put down your name? Think of being a heap of charred offal, like a haltered horse burnt in his stall; and all in one flash!'

'You pretended envoy extraordinary and minister plenipotentiary to and from Jupiter Tonans,' laughed I; 'you mere man who come here to put you and your pipe-stem between clay and sky, do you think that because you can strike a bit of green light from the Leyden jar, that you can thoroughly avert the supernal bolt? Your rod rusts, or breaks, and where are you? Who has empowered you, you Tetzel, to peddle round your indulgences from divine ordinations? The hairs of our heads are numbered, and the days of our lives. In thunder as in sunshine, I stand at ease in the hands of my God. False negotiator, away! See, the scroll of the storm is rolled back; the house is unharmed; and in the blue heavens I read in the rainbow, that the Deity will not, of purpose, make war on man's earth.'

'Impious wretch!' foamed the stranger, blackening in the face as the rainbow beamed, 'I will publish your infidel notions.'

The scowl grew blacker on his face; the indigo circles enlarged round his eyes as the storm-rings round

the midnight moon. He sprang upon me; his triforked thing at my heart.

I seized it; I snapped it; I dashed it; I trod it; and dragging the dark lightning-king out of my door, flung his elbowed, copper sceptre after him.

But spite of my treatment, and spite of my dissuasive talk of him to my neighbours, the Lightning-rod man still dwells in the land; still travels in storm-time, and drives a brave trade with the fears of man.

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SECTION 3

AERIAL BATTERIES

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LIGHTNING BATTERIES—REMARKABLE INVENTION.

The earth and the atmosphere are vast magazines of electricity. Sometimes the heavens become illuminated for several hours with broad and successive sheets of "nature's dread artillery," a single discharge of which is capable of prostrating the loftiest tree that waves in the forest. Why cannot such a gigantic power which is furnished without cost by the operations of nature be held by bit and bridle like a noble steed and yoked at pleasure to the car of the useful arts? Franklin taught the world more than half a century ago how to rein in the fiery war-horse of the clouds, but up to the present day he has never been harnessed for useful purposes, and may not this be done now? The idea is a grand one, and M. Hippolite Charles Vion, engineer, of Paris, France, has endeavored to respond to the important question. He has invented and patented in France an apparatus for conducting natural electricity from the great laboratory of nature, and storing it up in magazines from which it is to be conveyed to operate machinery, to illuminate the streets in cities, and numerous other purposes. In hilly regions he is to conduct by rods the positive electricity from the atmosphere; and in valleys and low flat countries, he will elevate conductors and receivers to a great altitude by balloons connected to the earth by wires. The atmospheric conductors are connected by insulated wires with plates extending to a considerable depth in the earth, and the insulated reservoirs for storing up the electric fluid are situated midway between them. These are so arranged that by breaking and closing the circuit the current will be conveyed to any situation to effect the objects contemplated. As nature furnishes electricity in such exhaustless quantities, M. Vion, proposes to use it with his apparatus for the rapid development of vegetation in gardens and fields—a power which it has been shown to possess by experiments made at Kew, England, by Mr. Ronalds, but which by common means has hitherto been too expensive to employ. The ideas of M. Vion are certainly magnificent, and if his apparatus accomplishes all those operations which he proposes to execute, he will deserve a monument more enduring than that of the great Napoleon.

M. Vion has taken measures to patent his extraordinary apparatus in the United States.

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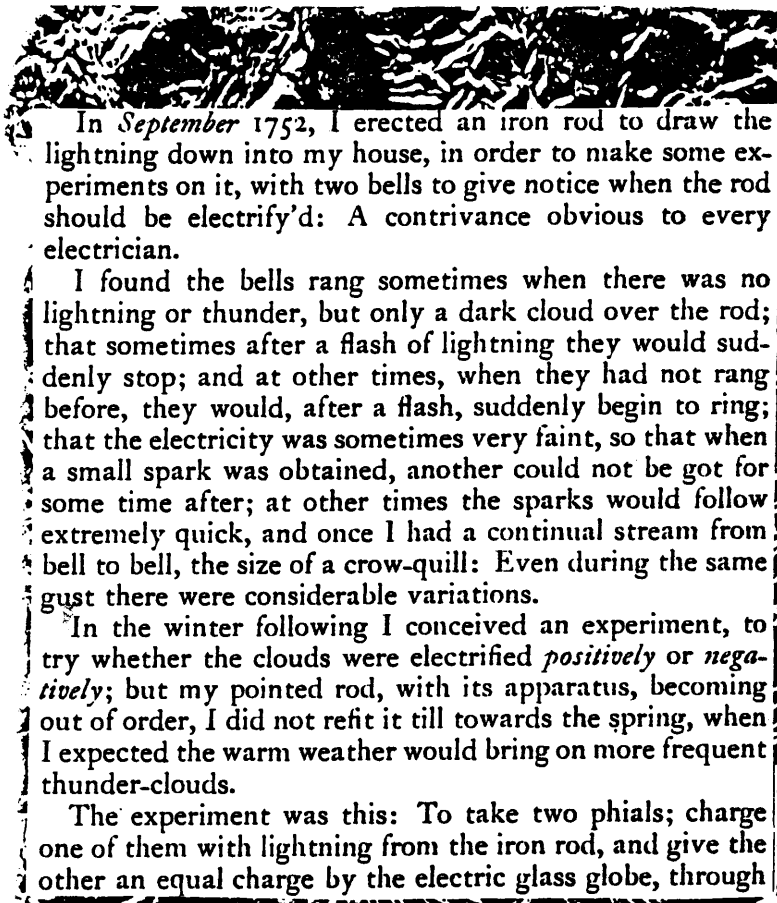
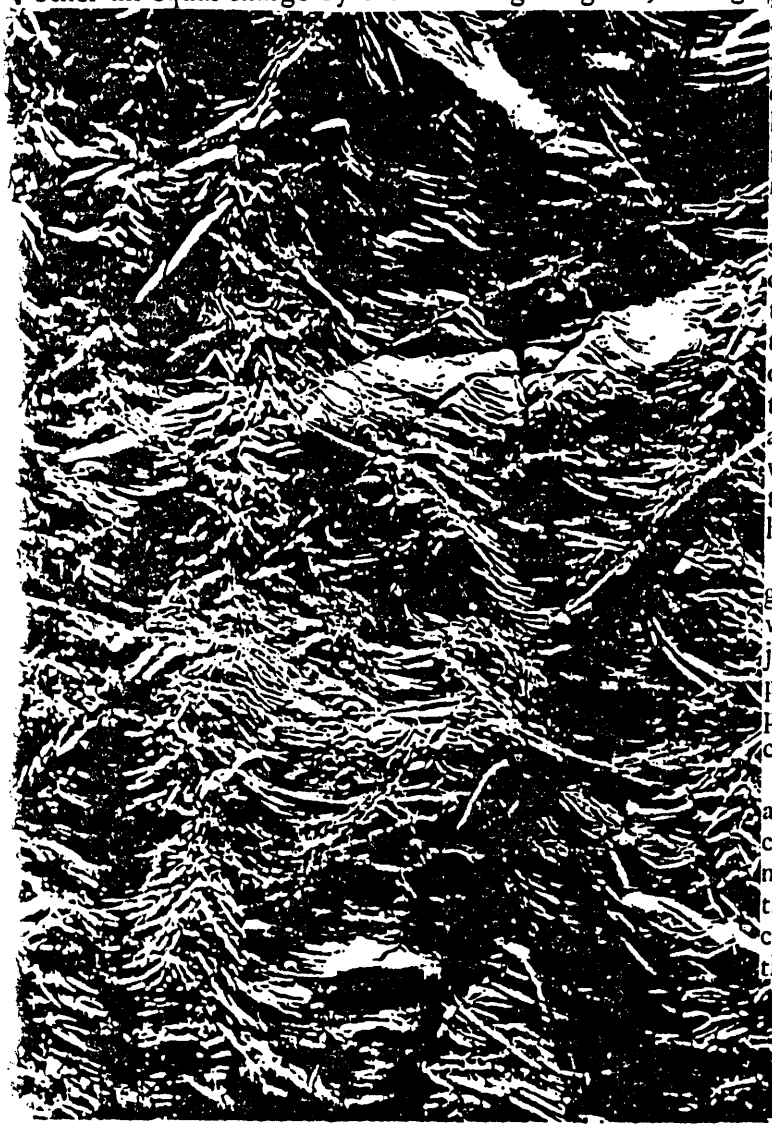


In *September* 1752, I erected an iron rod to draw the lightning down into my house, in order to make some experiments on it, with two bells to give notice when the rod should be electrify'd: A contrivance obvious to every electrician.

I found the bells rang sometimes when there was no lightning or thunder, but only a dark cloud over the rod; that sometimes after a flash of lightning they would suddenly stop; and at other times, when they had not rang before, they would, after a flash, suddenly begin to ring; that the electricity was sometimes very faint, so that when a small spark was obtained, another could not be got for some time after; at other times the sparks would follow extremely quick, and once I had a continual stream from bell to bell, the size of a crow-quill: Even during the same gust there were considerable variations.

In the winter following I conceived an experiment, to try whether the clouds were electrified *positively* or *negatively*; but my pointed rod, with its apparatus, becoming out of order, I did not refit it till towards the spring, when I expected the warm weather would bring on more frequent thunder-clouds.

The experiment was this: To take two phials; charge one of them with lightning from the iron rod, and give the other an equal charge by the electric glass globe, through the prime conductor: When charged, to place them on a table within three or four inches of each other, a small cork ball being suspended by a fine silk thread from the cieling, so as it might play between the wires. If both bottles then were electrified *positively*, the ball being attracted and repelled by one, must be also repelled by the other. If the one *positively*, and the other *negatively*; then the ball would be attracted and repelled alternately by each, and continue to play between them as long as any considerable charge remained.



Being very intent on making this experiment, it was no small mortification to me, that I happened to be abroad during two of the greatest thunder-storms we had early in the spring, and though I had given orders in my family, that if the bells rang when I was from home, they should catch some of the lightning for me in electrical phials, and they did so, yet it was mostly dissipated before my return, and in some of the other gusts, the quantity of lightning I was able to obtain was so small, and the charge so weak, that I could not satisfy myself: Yet I sometimes saw what heightened my suspicions, and inflamed my curiosity.

At last, on the 12th of *April*, 1753, there being a smart gust of some continuance, I charged one phial pretty well with lightning, and the other equally, as near as I could judge, with electricity from my glass globe; and, having placed them properly, I beheld, with great surprize and pleasure, the cork ball play briskly between them; and was convinced that one bottle was electrised *negatively*.

I repeated this experiment several times during the gust, and in eight succeeding gusts, always with the same success; and being of opinion (for reasons I formerly gave in my letter to Mr. *Kinnersley*, since printed in *London*) that the glass globe electrises *positively*, I concluded that the clouds are *always* electrised *negatively*, or have always in them less than their natural quantity of the electric fluid.

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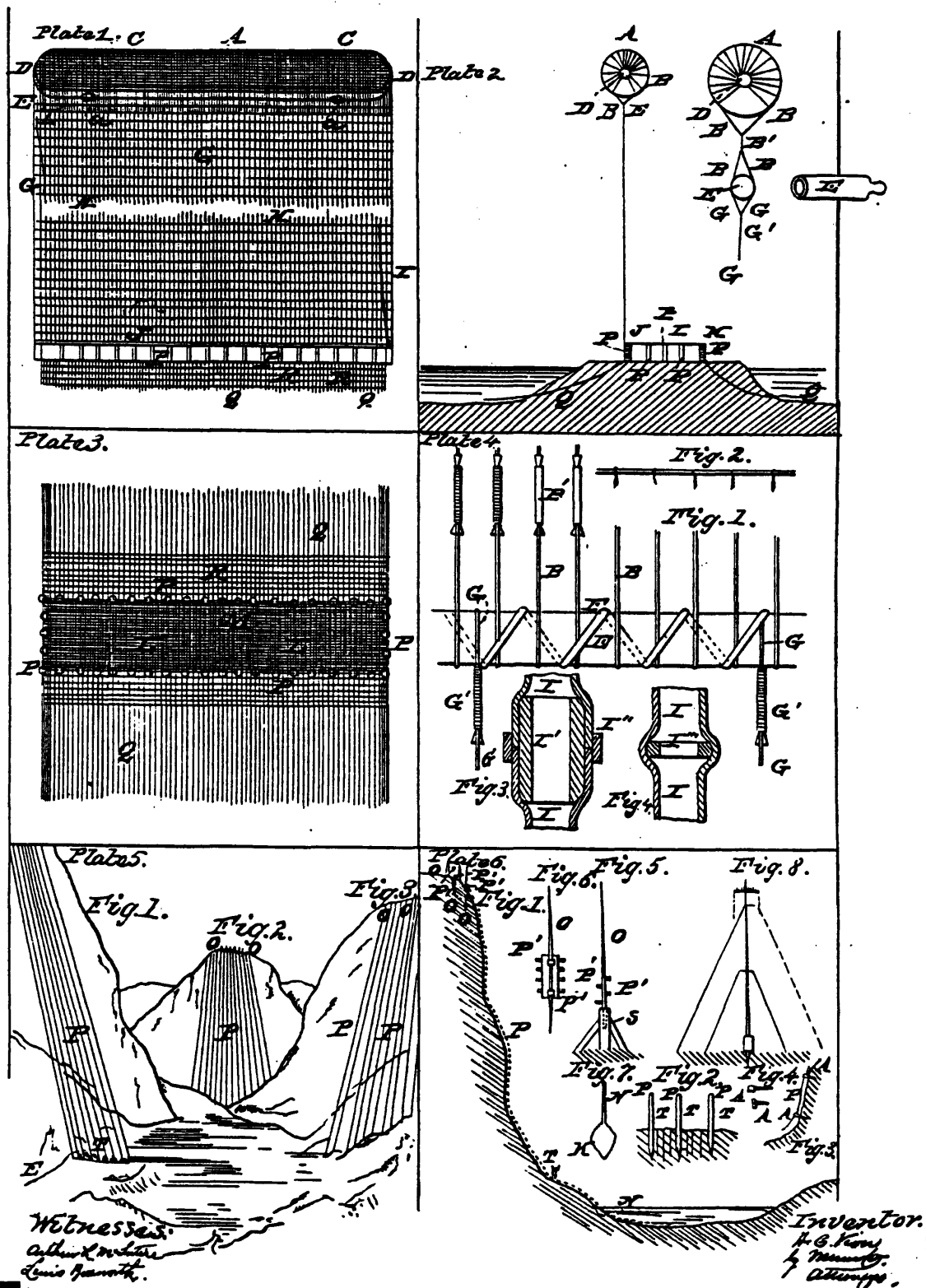
H. C. VION.

Electric Apparatus.

No. 28,793. Patented June 19, 1860.



ÆTHERFORCE

UNITED STATES PATENT OFFICE.

H. CHARLES VION, OF PARIS, FRANCE.

IMPROVED METHOD OF UTILIZING ATMOSPHERIC ELECTRICITY.

Specification forming part of Letters Patent No. **28,793**, dated June 19, 1860.

To all whom it may concern:

Be it known that I, HIPPOLYTE CHARLES VION, of Paris, in the Empire of France, engineer, have invented a new Mode of Obtaining Atmospheric Electricity and Terrestrial Electricity and its Industrial Applications; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, making part of this specification, in which—

Plate 1 represents a front elevation; Plate 2, a side elevation of an aerostat, in combination with certain other devices for obtaining atmospheric and terrestrial electricity; Plate 3, a plan of the device for obtaining terrestrial electricity; Plate 4, detached portions of the apparatus. Plate 5 shows a front view, and Plate 6 a vertical section and various details of the apparatus when applied in mountainous regions, the use of an aerostat being dispensed with.

The object of my invention is to form an electric pile of great power by using the positive electricity contained in the atmosphere, and the negative electricity contained in the earth, so as to make the electricity therein contained available for industrial purposes.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and operation.

A is aerostat of a tubular form closed at both ends. It is made of suitable material, so as to be impervious to air. Its dimensions are such as to give it great ascensional power when filled with gas.

a a are valves in the surface of the aerostat, to be opened when the inflation of the aerostat should become too great.

A long india-rubber tube, I, communicates with the interior of the aerostat, being attached to the latter, near one end of its ends D, as seen in Plate 1, while the lower end of the tube I is attached to a gasometer, (not shown in the drawings.) The gasometer is to be fed with hydrogen gas, produced by the action of the pile itself, the negative wires of which (afterward to be described) enter a body of water at or near the base of the apparatus and decompose the water so as to produce the hydrogen gas. As the aerostat is supposed to be at a considerable height the tube I must be of corresponding length, and is constructed of a number of tubes, short wooden tubes I′ being inserted where the tubes I are joined, and a fastening-ring, I″, being slipped over each of the joints, as seen in Fig. 3 of Plate 4. At certain distances the tube I is fastened to the net-work of the positive wires (afterward to be described) in order to secure the tube against the action of the wind, and at each of these fastening-places a washer, I‴, is inserted in the tube in order that the tube shall not be compressed by the wire or other means employed to fasten it to the net-work of positive wires. (See Fig. 4, Plate 4.)

The aerostat is surrounded with a net-work of wires, one layer of the wires, C, being parallel with the axis of the aerostat and fastened to rings D at both ends of the aerostat, and the other layer of wires, B, extending partially around the aerostat at right angles to the wires C. One end of each of the wires B extends around an iron tube, E, some distance below the aerostat and meets the other end of it between the tube E and the aerostat. The two ends are fastened together by a ligature, B′. (See Fig. 1, Plate 4.) Each end of the tube E terminates into a ball, *e*. The wires B are fastened to the surface of the tube E by means of a helical wire, F, wound around the tube and across the wires B, as seen in Fig. 1, Plate 4. The upper ends of long vertical wires G are also wound around cylinder E, each wire G between two of the wires B, and the ends secured by a ligature, G′, as seen in Fig. 1, Plate 4. The helical wire F is also wound across the wires G, so as to keep them in their places on tube E.

The vertical wires G, which are to be the conductors of the positive electricity of the atmosphere, must be of a length proportionate to the desired efficacy of the electric pile, and the size and ascensional power of the aerostat must, of course, be adequate to sustain the weight of and keep suspended the wires G, (a weight still further increased by the horizontal cross-wires H, with which the vertical wires G are interlaced, in order to form a net-work not liable to be deranged by the action of the winds or similar influences.) The two outside wires, G, are stronger than the rest of them, and their lower ends are fastened to dyna-

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mometers of any suitable construction. These dynamometers are attached to the ends or a massive iron cylinder, J, and they serve to indicate the tension in the outside wires, G, and the corresponding ascensional power of the aerostat. According to the reading of these dynamometers the aerostat has to be supplied (through tube I) with more or less gas. The lower end of each of the wires G is wound around the cylinder J, and secured by ligatures similar to those above described. The wires G are all insulated (by a coating of gutta-percha or similar substance,) except where they are in contact with tube E and with cylinder J, and a similar insulating coating is laid on cylinder J, after the lower ends of the wires G have been fastened to it.

Another cylinder, K, similar to J, is placed at some distance from and parallel to cylinder J. It is connected with cylinder J by wires L, wound around both cylinders and interlaced with cross-wires M. The wire-work L M and cylinders are insulated (in a manner already described) against outside influences, so that the only electric communication between the two cylinders will be through the wires L. The two cylinders are placed upon insulated columns P. The cylinder K may be used as a substitute for cylinder J, and vice versa, whenever repairs become necessary. Insulated branch wire or wires are attached to the cylinders J K and wires L, so as to conduct the positive electricity obtained from the atmosphere by means of the above-described apparatus to wherever it is desired for industrial purposes. The insulated wires Q (interlaced with cross-wires R) are placed on the ground underneath and parallel to the positive wires L. Both ends of each of the wires Q are sunk into the earth or submerged in water, and fastened to a metallic plate coated with a metal not subject to oxidation. These wires Q are the conductors for the negative electricity of the earth, and a branch wire or wires attached to the wires Q serve to transmit the negative terrestrial electricity to wherever it is wanted for industrial or other purposes.

By uniting to the ends of the positive and the negative branch wire or wires a powerful electric current will be obtained, one pole of which is the atmosphere and the other the earth, and may be applied to any suitable useful purpose.

I will now proceed to describe the modification of the above-described apparatus when to be applied in mountainous countries.

P represents the positive electric copper or other metal wires coated over with an insulating substance. The upper ends of each of the positive wires is soldered to a prompter, O, at P′, Figs. 1, 5, and 6, Plate 6. The lower portion of each of the positive-wires is secured to an insulator, T, Fig. 2, Sheet 6. The positive wires are held above the ground by joints A, Figs. 3 and 4, Sheet 6, projecting from the soil at suitable distances from each other. The wires P are intended to follow the inequalities of the ground on which they are laid.

The prompters O, Figs. 5 and 6, Sheet 6, are iron rods sharpened to a point and silvered or coppered at their upper ends. The lower part of the prompter is fastened into a pole, S, covered with tar, which isolates the prompter and holds it in a firm position. A large metallic plate may be soldered to each prompter, as shown in Fig. 6. The positive wires may be soldered to the rod of each prompter or to the plate which is fastened thereto.

One or more branch lines, E, are soldered up to the positive wires to transmit the positive atmospheric electricity for which the wires P are the conductors to any desirable point.

N are negative iron or other metal conductors coated with an insulating substance. The upper ends of these wires rest on the ground near the positive insulators. The lower ends of these wires are soldered to a metallic plate or plates, V, Fig. 7, Plate 6, coated with a metal not subject to oxidation. The negative wires are sunk into the ground at very great depth or into wells, rivers, or into the sea. The negative electric branch wires are attached to the negative conductors N in the same manner as the positive branch wires are to the positive conductors. The branch wires and the soldering are coated over with an insulating substance. They are intended to carry the negative terrestial electricity to any desired point.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The peculiar arrangement of means herein specified, whereby I am enabled to use the positive electricity contained in the atmosphere and the negative electricity contained in the earth, and thus form an electric pile of considerable power and make the electricity therein contained available for industrial purposes, as set forth.

2. The combination of an aerostat and vertical wire-work with a tube, I, for admitting gas into the aerostat, in the manner and for the purposes above set forth.

CHARLES VION.

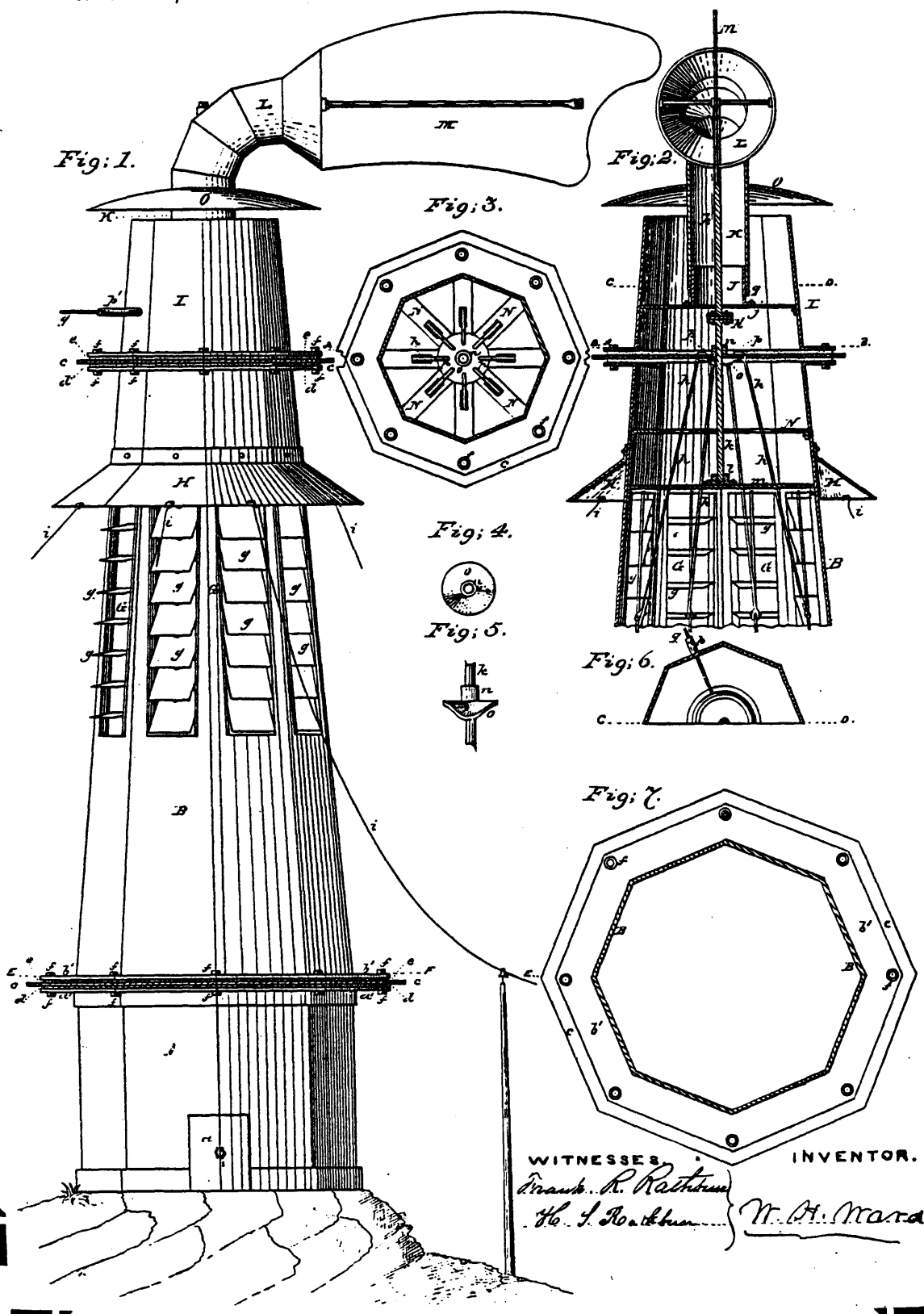
Witnesses:
HARRY W. SPENCER,
A. GUION, Jr.

ÆTHERFORCE

WILLIAM H. WARD.

Improvement in Collecting Electricity for Telegraphing, &c.

No. 126,356. Patented April 30, 1872.



WITNESSES.

Frank R. Rathbun

H. L. Rathbun

INVENTOR.

W. H. Ward

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126,356

UNITED STATES PATENT OFFICE.

WILLIAM HENRY WARD, OF AUBURN, NEW YORK.

IMPROVEMENT IN COLLECTING ELECTRICITY FOR TELEGRAPHING, &c.

Specification forming part of Letters Patent No. 126,356, dated April 30, 1872.

I, WILLIAM HENRY WARD, of Auburn, in the county of Cayuga and State of New York, have invented an Electrical Tower for Accumulating Natural Electricity for Telegraphic Purposes, of which the following is a specification:

My invention consists of a tower for the purpose of receiving and imparting natural electricity, so as to be in constant contact with that upper stratum of electricity which surrounds the earth, by tapping which a never-failing supply is formed when brought into contact with the earth, as will be more fully explained hereinafter.

In the accompanying drawing, Figure 1 represents a side elevation of my improved electrical tower. Fig. 2 is a vertical central section of the upper part of the same. Figs. 3, 4, 5, 6, and 7 are detached views of several parts of the same.

The tower is constructed in three separate sections, a lower, a middle, and an upper one, and is placed on elevated mountain tops or peaks. The lower one, A, is a mere shell, having a door, *a*, and is constructed of any material suitable for the purpose. It is insulated from the middle portion B by means of a glass diaphragm, *c*, held between similar diaphragms of rubber, *d*, and of gutta-percha, *e*, by means of flanges *a'* and *b'*, formed on the upper end of the lower portion and the lower end of the middle portion of the tower respectively. These flanges are secured to each other by insulated bolts *f*. The middle portion B is provided with suitable openings or windows, G, having shutters or slats *g* pivoted in them, so that, by means of raising or lowering rods *h*, suitably connected to said shutters, the openings G may be shut or opened. A projecting roof, H, is formed on or secured to the middle portion B just over the openings G, and which serves the double purpose of protecting the said openings from the effects of the weather, such as rain or snow, and also for receiving the aerial electricity, which may be drawn from it by wires *i*, for land-line purposes. Above this roof H the middle portion of the tower is again insulated by diaphragms of glass, rubber, and gutta-percha from the upper portion I of the tower in the same manner as it is insulated from its lower portion. A circular plate, *j*, secured on the inside of this upper portion, bears a short tube, J, which is surrounded by the tube K of the ventilator L, from which latter the vane M extends; or the tube J may be held by rods extending from the side of the tower centrally. This ventilator is supported by a rod or shaft, *k*, firmly attached to the tube K, and having its lower bearing in a step, *l*, on a brace, *m*, crossing the middle portion B of the tower just above the openings G. This rod or shaft *k* is formed in two parts, insulated from each other, as shown at *k'*. On the lower portion of this shaft *k* is keyed or otherwise secured a sleeve, *n*, from which a horizontal serpentine cam-plate, *o*, shown in detail in Figs. 4 and 5, extends, over the rim of which the forked ends *p* of rods *h* seize, and which is so arranged relatively to the vane M and the shutters or slats *g* that the revolution of the vane by the wind will open the windward and close the leeward shutters or slats *g* and openings G by means of the rods *h*. Guide-plates or their equivalents N, provided with suitable openings, through which the rods *h* pass, keep the upper forked ends *h* of the latter in constant contact with the cam-plate *o*, which raises or lowers the rods, and consequently opens or closes the openings G as it revolves. A circular roof, O, extends from the tube K of the ventilator so as to cover and protect the open upper end of the tower. The upper portion I of the tower is provided with an insulating-tube, *p'*, through which a copper wire, *q*, enters the portion I of the tower, and is coiled around the tube J just under the tube K, which wire may connect that upper portion of the tower with any land line of wires. The upper portion I of the tower, as well as the tubes J K, may be constructed of zinc, while the vane may be made of zinc, copper, or any equivalent material, which, with the zinc and the moisture of the atmosphere, would form an electrical current. As the vane revolves it opens the openings to windward and closes those to leeward, thus helping to drive an aerial current of electricity into the insulated middle portion of the tower, which current passes upwardly through the upper portion of the tower and out through the ventilator or the top, which is swung around by the wind or aerial electrical current, thus forming a draught in addition to the closing of the shutters or openings to leeward, by means

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of which draught the electrical current is forced upwardly and out at the vane. The top portion of the tower is of course completely insulated from all below it, including the revolving central ventilator-shaft. As the middle portion of the tower allows the electrical current of atmosphere, wind, &c., to pass within, up, and out at the top it forms a continuous current, whereby the tower is receiving continually fresh and new supplies of electricity, which can be drawn from the projecting roof H by the wires *i* for the use of land lines of telegraphs or for other purposes, such as light, heat, &c. By the use of aerial electricity I entirely dispense with artificial batteries, forming my circuit merely by connecting the aerial current with the earth current. For instance, to bring Buenos Ayres, in South America, into direct connection with New York, the following plan would be pursued: One electrical tower is erected on Pike's Peak or any other suitable high mountain in North America, and another similar tower on some suitable peak of the Andes in South America. The former would, by means of land-lines, be connected directly with Denver, which place is again connected with all the prominent cities of the States. In a similar manner the southern tower is connected by land-lines with the prominent cities via Quito. New York telegraphs to the tower on Pike's Peak, and the operator having connected the land-line with the aerial current, the signals are transmitted through the aerial current to the tower in the Andes in South America, and from there—the land-lines being suitably connected with the aerial current—to Quito and Buenos Ayres. In this manner a message would be sent entirely by natural electricity in place of artificial. In the same manner a message may be sent across the ocean by having a high tower on each continent, each of which towers would have to be, of course, through land-lines connected with the earth to enable the ground current with the aerial current to form a circuit. Different towers may be erected on the different continents, and if they are all what is technically called hooked on—that is to say, connected to the earth—a signal given at one tower will be repeated at all the towers, they being connected with each other by the aerial current. If the earth-connection is severed, or the insulation with the tower destroyed, there is no power; but by insulating the tower and concentrating its force to a point, bringing the same corresponding effect from the earth current in connection, an exceedingly powerful electrical force is created.

Having described my invention, I claim—

1. A tower constructed so as to collect, hold, distribute, and utilize aerial currents of natural electricity for telegraphic and other purposes, essentially as described.

2. A tower for collecting aerial currents of natural electricity, constructed of three sections, insulated from each other and the earth, or their equivalents, substantially in the manner described.

3. In an electrical tower, the combination of the shutters or slats *g* with the ventilator-vane in such a manner that the vane, through suitable mechanism, always opens the shutters to windward and closes them to leeward, substantially as described.

4. In an electrical tower, the collecting, distributing, and protecting roof H, substantially as and for the purpose described.

5. The combination of the tube J and ventilator L with its vane M and the coiled wire or small cable *q*, substantially as and for the purpose set forth.

6. The combination of the insulated shaft *k* and rods *h* having forked upper ends *k'* with the shutters or blinds *g*, serpentine cam-plate *o*, and ventilator L, substantially as and for the purpose described.

The above specification of my improvement, being a tower for accumulating natural electricity for telegraphic purposes, signed this 29th day of June, A. D. 1871.

W. H. WARD.

Witnesses:

A. L. PALMER,

J. H. STARIN.

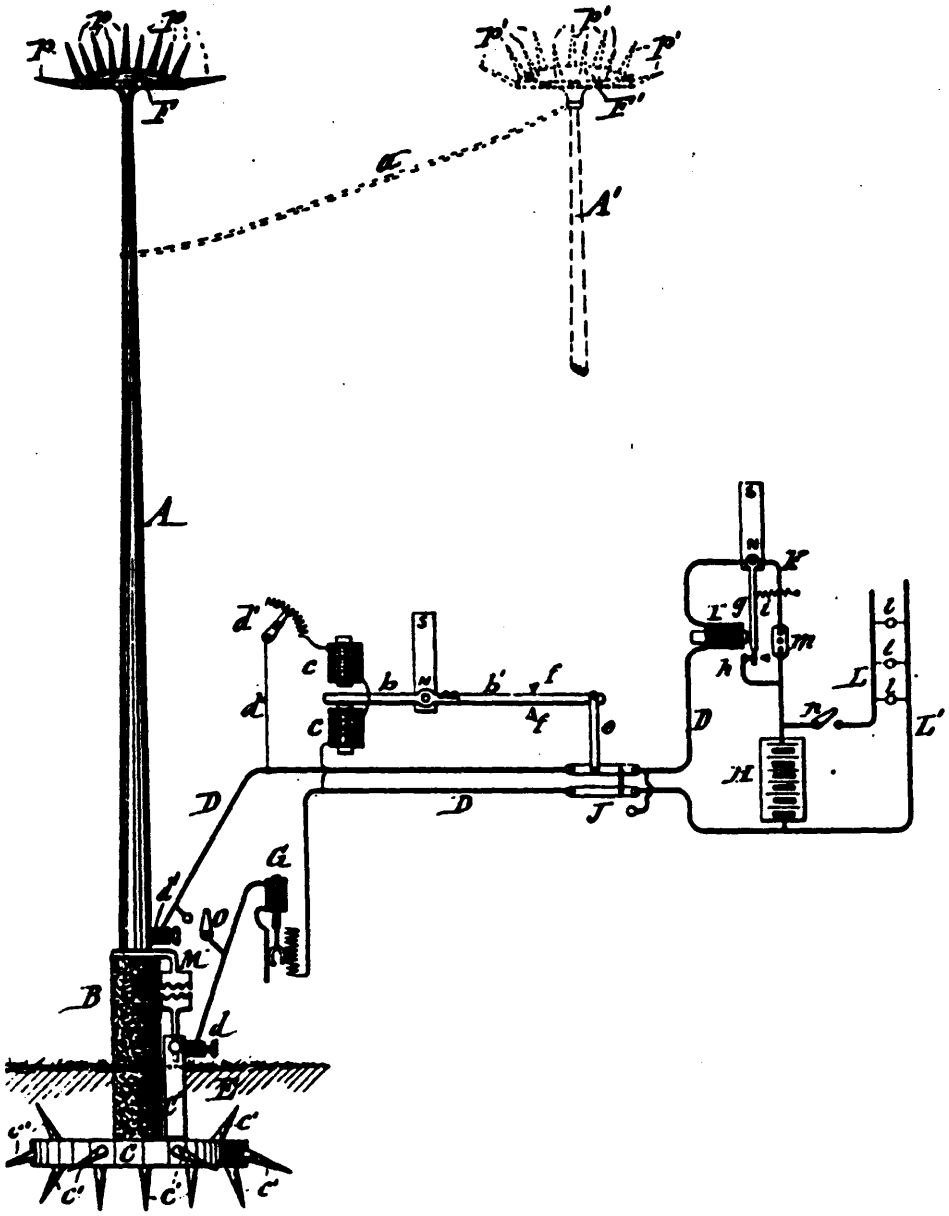
ÆTHERFORCE

(No Model.)

M. W. DEWEY.

METHOD OF UTILIZING NATURAL ELECTRIC ENERGY.

No. 414,943. Patented Nov. 12, 1889.



WITNESSES:

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A. F. Walz.

INVENTOR

Mark W. Dewey

BY

Hull, Lass & Dodd

ATTORNEYS

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UNITED STATES PATENT OFFICE.

MARK W. DEWEY, OF SYRACUSE, NEW YORK, ASSIGNOR TO THE DEWEY CORPORATION, OF SAME PLACE.

METHOD OF UTILIZING NATURAL ELECTRIC ENERGY.

SPECIFICATION forming part of Letters Patent No. 414,943, dated November 12, 1889.

Application filed May 1, 1889. Serial No. 309,171. (No model.)

To all whom it may concern:

Be it known that I, MARK W. DEWEY, of Syracuse, in the county of Onondaga, in the State of New York, have invented new and useful Improvements in the Method of Utilizing Natural Electric Energy, of which the following, taken in connection with the accompanying drawings, is a full, clear, and exact description.

The object of this invention is to provide a method whereby natural electrical energy—such as the so-called "atmospheric electrical energy," or electrical energy that may be derived from the difference of potential existing between two points, one being the earth and the other the atmosphere at an elevation above the earth—may be collected or utilized for the various uses to which electricity is applied.

It has been found that the presence of electricity in the upper regions of the atmosphere is not confined to thunder-clouds, but can be detected at all times and often in great quantities in different conditions of the atmosphere. In fine weather this electricity is mostly positive; but in showery or stormy weather negative electricity is as frequently met with as positive, and it is in such weather that the indications of electricity, whether positive or negative, are usually the strongest. It has also been found that as we proceed farther from the earth's surface, whether upward from a level plane thereof or horizontally from an elevation, the potential of points in the air becomes more and more different from that of the earth, the difference being, in a broad sense, simply proportional to the distance; hence we can infer that there is electricity residing on the surface of the earth, the density of which at any moment in the locality of observation is measured by the difference of potential found to exist between the earth and a given point in the air near it. The results of observations show that the variations of the electricity residing in the atmosphere is the main cause of the variations of the electricity on the surface of the earth. A charged cloud or body of air induces electricity of the opposite kind to its own on the parts of the earth's surface over which it passes and produces such variations. The difference of potential in increasing the distance from the earth is due to electricity induced on the surface of the earth by opposite electricity in the air overhead, and the air being a non-conductor the electricities are unable to combine. As electrical density is greater on projecting parts of a surface than on those which are plane or concave, stronger indications are obtained on hills than in valleys, if the collecting apparatus be at the same distance from the ground in both cases. The average difference of potential is greater in the winter than in the summer. Little or no effects can be obtained within inclosures or under-trees, as they tend to screen the apparatus.

Inasmuch as electricity travels in preference through the best conductors, it follows that if a path of low resistance is formed (such as the erection of a metal pole) to a sufficient elevation above the earth the electricities in the atmosphere and that on the surface of the earth will tend to combine and travel through the said path in a current or currents, and if this pole terminates in a metal point or a number of such points the earth and clouds exchange their opposite electricities without a disruptive discharge—as the lightning—but in a slow and gradual way through convection. Besides supplying the top of the pole with points, a metal plate to which the said points are fixed attracts the opposite electricity in the atmosphere. In order to obtain a greater and increased effect, a large metal plate is buried at the foot of the pole and electrically connected therewith, and is provided with points or branches extending in different directions in the ground. The plate and branches may be surrounded by metallic refuse, coke, or other good conducting substance. The metallic points on the top of the pole should be sharp, and preferably of copper, and may be platinized, gilded, or galvanized to prevent corrosion. It having been ascertained by practical experiments that either a flame or dropping water at an elevation above the surface of the earth produces convection of electricity, it is obvious that such means may be employed in place of the points hereinbefore referred to. As the electricity in the atmosphere is some-

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times positive and other times negative, the direction of the currents is not always the same—that is, the atmospheric electrical energy is composed of a current of an alternating character, flowing in one direction on an average about as much of the time as in the opposite direction, but the length of the current in a certain direction, or the lengths of time between reversals or changes in the direction of its flow, is greatly varied. This and also the varied strength of the currents have prevented the utilization of atmospheric electrical energy in commercial quantities for the various purposes for which electricity is generally employed. In order to utilize such a current or currents, they should be transformed into a continuous direct current of uniform strength. The apparatus for accomplishing the transformation of atmospheric electricity into a direct current of uniform strength is susceptible of being greatly modified. The preferred form of apparatus, however, for carrying the invention practically into effect I will now proceed to describe to show that the method is capable of actual performance. Said apparatus is illustrated in the diagram accompanying this specification.

Referring specifically to said diagram, A represents a metallic pole, which is shown bare, but may be enveloped in suitable insulating material, if desirable. B is the base of the aforesaid pole, which base is of insulating material set in the ground E. C is a large metal plate beneath the said base, and has points or branches *c'* extending therefrom in different directions in the ground. C'' is a metallic post extending from the said plate above the surface of the ground and having a terminal *d* of the circuit D. On the top of said pole is mounted a metallic cap F, consisting, preferably, of a convex disk provided with sharp iron or copper points *p*, which project in all directions from the same. As before mentioned, the said points may be plated with a suitable metal that forms a good conductor and prevents corrosion. Similar caps F' may be placed on other insulated poles, as A', in the vicinity, and connected with the main pole A by an electric conductor *a*, for increasing the effect. The pole A' may be of wood, and the pole A may also be of the same material if provided with a metal conductor within or on the outside, extending from the cap to the other terminal *d'* of the circuit D. The said circuit D leads from the terminal *d* through an automatic variable resistance G, thence to one of the poles of a secondary or storage battery H, and from the other pole of said battery through an automatic current-regulator to the terminal *d''*. An automatic current-reverser or pole-changer J is located in the said circuit for reversing the current whenever there is a change in its direction, so that it may be rectified or straightened during transit and caused to travel at all times whether its direction is toward or from the earth in one and the same direction through a portion of the circuit containing the secondary battery. The reversals are accomplished automatically by means of a pivoted polarized armature *h*, located between two electro-magnets *e e*, having their coils included in a shunt-circuit between the leads of the circuit D. The magnets are wound so that a north pole will be presented to the armature on one side and a south pole on the other. When the current is flowing in a certain direction, the said polarized armature will be repelled by one magnet and attracted by the other, and thereby moved to one side. When the current changes its direction through the magnets, the poles of the said magnets are reversed and the armature is both repelled and attracted to the other side. An arm *h'*, of diamagnetic material, is fixed to and extends from the armature and is moved by the same. Between a movable end of the arm and the said current-reverser is a pivoted connection or link *e*, by which the motion of the arm is conveyed to the reverser. Stops *f* are provided for limiting the movement of the said arm, and an adjustable resistance *d'* is included in the shunt *d'''* to regulate the current through the same.

The current-regulator hereinbefore referred to prevents short-circuiting or the rapid discharge of the secondary battery into the air and ground when the strength of said battery-current becomes greater than that passing to the battery. Said regulator is composed of an electro-magnet I, having its coil in the circuit D. A pivoted polarized armature *g* is connected at its pivot to one terminal of the coil of said magnet, and when the current is flowing to the battery said armature is attracted by the magnet I and held in contact with the stop *h*, to which the terminal of the secondary battery is connected. In the aforesaid condition a free or low-resistance path for the current is provided to the battery; but when the battery-current exceeds the charging-current the magnet-poles are reversed and the armature is repelled by the magnet, and the free path of the circuit is broken between the armature *g* and stop *h*. In order to maintain the armature in the latter position until the charging-current has been increased in strength above that of the battery-current or discharging-current, and so that the said regulator will automatically operate, a shunt path K of high resistance is provided around the armature *g* and stop *h*. The high resistance of the said shunt is obtained by including a rheostat *m*. This shunt path or circuit K, with the resistance, permits a small but sufficient amount of current to flow through the magnet I to hold the armature away from the stop *h* until the current is reversed, and then move the armature back to stop *h* to close the free or low-resistance path. A spring *i* is provided to assist the movement of the armature from the magnet when it is repelled by the same.

The electric current may be directly con-

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ducted to translating devices—such as lamps or electromotors; but, as hereinbefore stated, said current is preferably employed to charge one or more cells of the secondary battery H, and this battery stores or accumulates the electrical energy and supplies the said translating devices. To illustrate the latter feature, leads or wires L and L′ are extended from the poles or electrodes of said battery, and translating devices, in the shape of incandescent lamps *l*, are connected with the said wires in multiple arc. In the wire L is a common circuit maker and breaker *n* to close and open the circuit to the lamps. The said battery may be charged in series or parallel.

The automatic variable resistance G maintains the current flowing through the circuit D approximately uniform by increasing the resistance therein upon an increase of strength. Said resistance is not absolutely necessary and may be dispensed with.

The lightning-arrester M is to short-circuit a very heavy current to prevent the same from passing through the other parts of the apparatus and injuring it. A low-resistance shunt O, with a circuit maker and breaker therein, is connected between the leads of the circuit D, near the terminals *d* and *d′*, to completely short-circuit the apparatus when desired.

Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The method of utilizing atmospheric electrical energy, consisting in conducting the electric current or currents between the earth and a point in the atmosphere at an elevation above the earth, rectifying or straightening the currents during transit, and storing or accumulating the electrical energy of said rectified current or currents.

2. As preliminary steps in the method of utilizing atmospheric electrical energy, conducting the electric current or currents through a path of low resistance between the earth and the atmosphere at an elevation above the earth, maintaining an approximately uniform strength of current and rectifying or straightening the same during transit.

3. As preliminary steps in the method of utilizing atmospheric electrical energy, conducting the electric current or currents through a path of low resistance between the earth and the atmosphere at an elevation above the earth, and rectifying or straightening said currents during transit.

4. The method of utilizing atmospheric electrical energy or deriving energy from the difference of electrical potential existing between the earth and a point or points in the atmosphere at an elevation above the earth, consisting in conducting the current or currents between the two points through a path of low resistance, rectifying or straightening the said currents in a portion of the path during transit, and storing or accumulating the electrical energy thereof.

5. The method of utilizing atmospheric electrical energy or deriving energy from the difference of electrical potential existing between the earth and a point or points in the atmosphere at an elevation above the earth, consisting in conducting the current or currents between the two points through a path of low resistance, maintaining an approximately uniform strength of current, rectifying or straightening the said currents in a portion of the path during transit, and storing or accumulating the electrical energy.

6. The method of utilizing atmospheric electrical energy composed of a current of a varied alternating character, consisting in conducting the electric current or currents through a path of low resistance between the earth and the atmosphere at an elevation above the earth, and then accumulating the electrical energy of said current or currents while flowing in both directions in one or more cells of a secondary or storage battery, as described.

In testimony whereof I have hereunto signed my name this 29th day of April, 1889.

MARK W. DEWEY. [L. S.]

Witnesses:
C. H. DUELL,
C. L. BENDIXON.

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No. 674,427. Patented May 21, 1901.

A. PALENCSÁR.

APPARATUS FOR COLLECTING ATMOSPHERIC ELECTRICITY.

(Application filed July 10, 1900.)

(No Model.) 3 Sheets—Sheet 1.

Fig: 1.

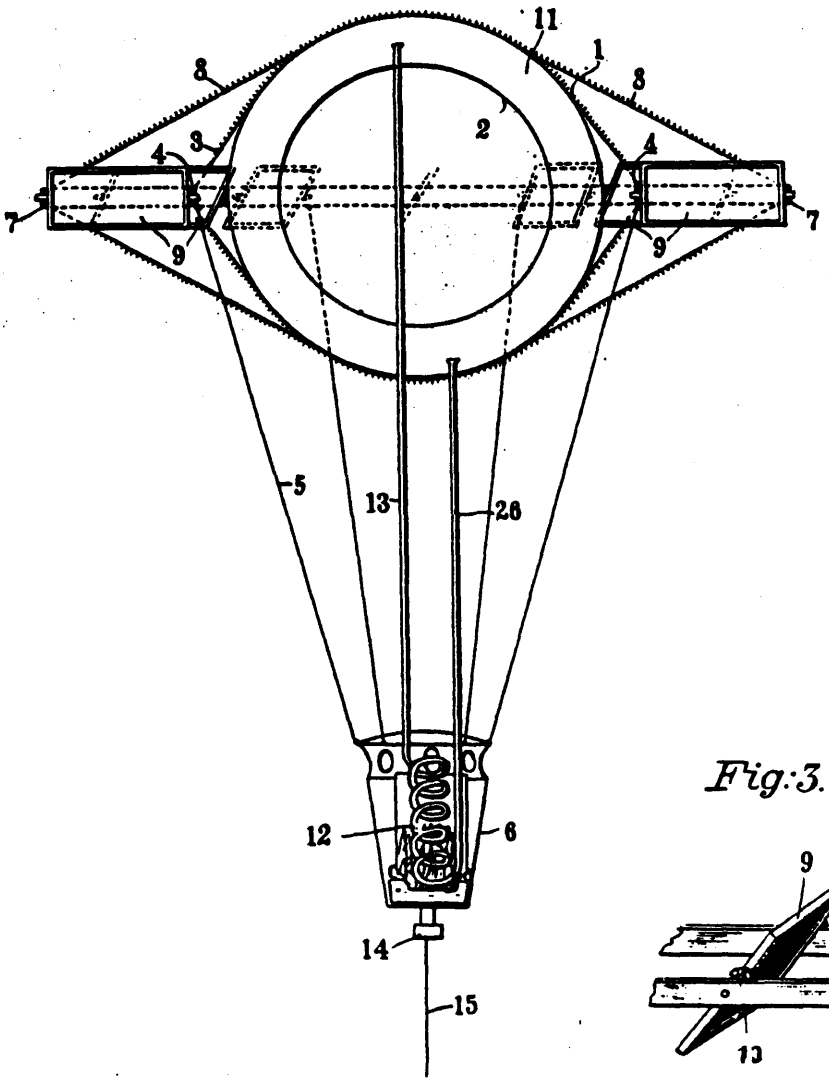
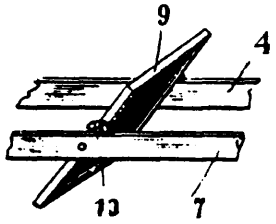


Fig: 3.



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ÆTHERFORCE

No. 674,427. Patented May 21, 1901.

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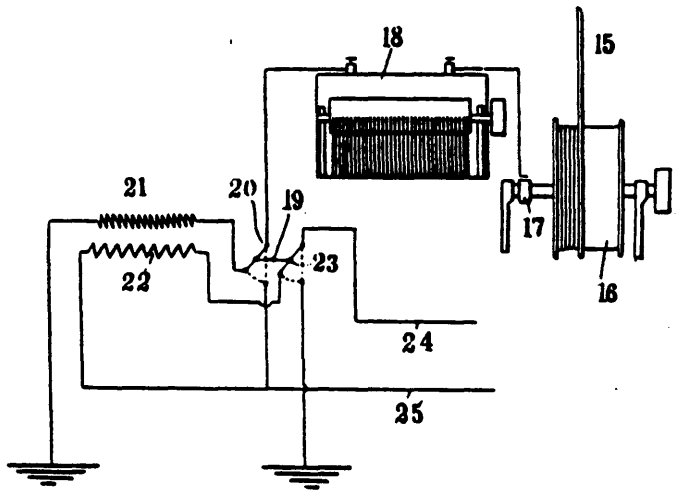
APPARATUS FOR COLLECTING ATMOSPHERIC ELECTRICITY.

(Application filed July 10, 1900.)

(No Model.) 3 Sheets—Sheet 2.

Fig. 2.



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ATHERFORGE

No. 674,427. Patented May 21, 1901.

A. PALENCSÁR.

APPARATUS FOR COLLECTING ATMOSPHERIC ELECTRICITY.

(Application filed July 10, 1900.)

(No Model.) 3 Sheets—Sheet 3.

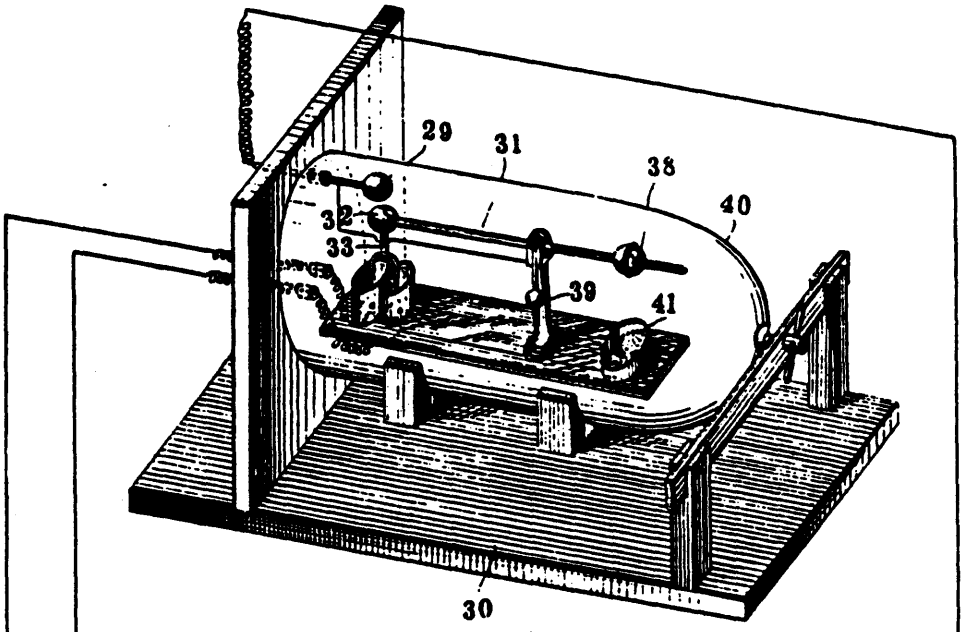
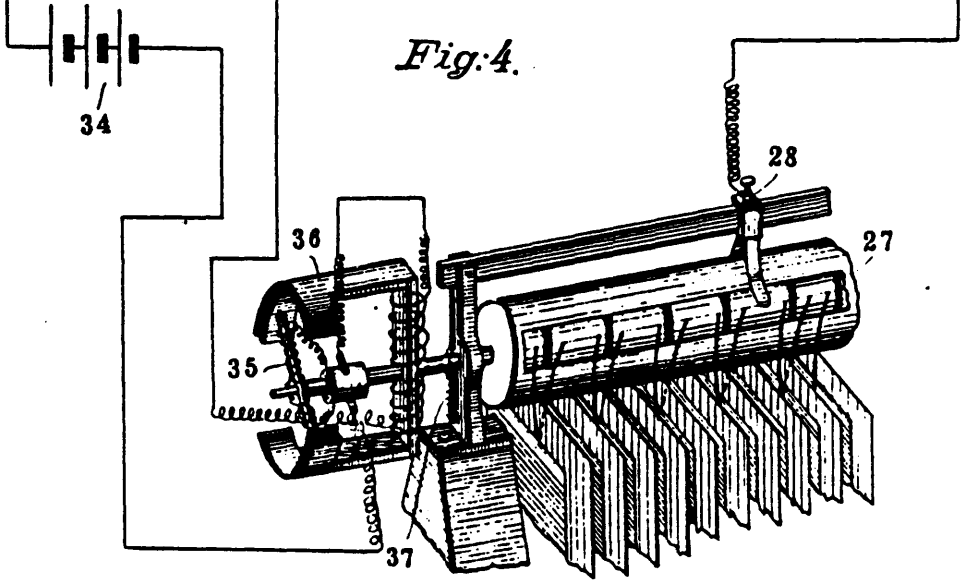


Fig. 4.



WITNESSES:

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Attorney

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BY

Richards & Co

ATTORNEYS

ÆTHERFORCE

UNITED STATES PATENT OFFICE.

ANDOR PALENCSÁR, OF BUDA-PESTH, AUSTRIA-HUNGARY.

APPARATUS FOR COLLECTING ATMOSPHERIC ELECTRICITY.

SPECIFICATION forming part of Letters Patent No. 674,427, dated May 21, 1901.

Application filed July 10, 1900. Serial No. 23,102. No model.

To all whom it may concern:

Be it known that I, ANDOR PALENCSÁR, a subject of the King of Hungary, residing at Buda-Pesth, Austria-Hungary, have invented a certain new and useful Apparatus for Collecting Atmospherical Electricity, of which the following is a full, clear, and exact specification.

The present invention concerns an apparatus for collecting and driving or conducting atmospherical electricity which renders it practicable to obtain material quantities of the same in serviceable form.

The experiments made hitherto have been limited to deviating or conducting the electricity by simple lightning-rods without making allowance for the progress of the theory of atmospherical electricity. It is obvious that only extremely small quantities of electricity can be collected in this manner, and, moreover, it was obtained in a form which entirely precluded its utilization. It is evident that a source of electricity of irregular yield can only be utilized by means of accumulators and for charging accumulators only a current of constant potential can be employed. The potential of electricity derived or deviated by means of a lightning-rod varies within wide limits, and, moreover, it is so high that it cannot be used at all for charging accumulators. All these drawbacks are remedied by the present invention, by which the atmospheric electricity is obtained in larger quantities with as low and constant a potential as may be desired.

The idea underlying the invention is based on the modern theory of atmospheric electricity, according to which it is produced by the condensation of steam or aqueous vapors, and that the increase of potential is effected by the concentration of the small drops of water into larger ones, as the proportion of the surface of the drops to the volume of same is materially reduced thereby. According to this theory the water-droplets floating in the layers of air are considered as vehicles or carriers of the electricity, and a rational system of the deviation of the atmospheric electricity must derive it from the water-drops. This is attained by the present invention in the following manner: A collecting-body of as large a surface as possible is provided with sharp needles. This is moved in the higher layers of air, while being continually heated by a suitable heating device. Owing to the heat the water-drops immediately ambient to the collecting-body will be evaporated, their capacity is gradually reduced, while the potential of the charge grows until it reaches an infinite height with infinite smallness of the drops. It is readily apparent that the whole charge of the drops as soon as they have been evaporated will have passed to the collector or collecting-body, from which it can be conducted. For the purpose of replacing the evaporated drops, which have been deprived of their charge by new-charged drops, the collector is moved in relation to the ambient air.

One way of carrying out the invention is represented in diagram in the accompanying drawings, in which—

Figure 1 is a longitudinal section of the collecting-balloon. Fig. 2 shows the deviating and conversion device, and Fig. 3 a detail. Fig. 4 is a diagrammatic perspective view of a form of automatic regulator for the rheostatic machine.

The apparatus consists of a balloon having two walls and covered with a light wire net, preferably of aluminium wire, said net being studded with needles. Besides, the balloon carries the net 3, on which the ring 4, made of a solid but light material, (wood, cane, &c.,) is fixed. This ring carries the basket 6 by means of the cords or ropes 5. On a level with the ring 4 is the ring 7, which is kept spread by the blades or wings 9, which are journaled in a manner to rotate easily. The ring 7 is kept fixedly in position by the cords or ropes 8. The blades or wings consist of a frame covered with light material, and their rotation in either direction is limited by the stops or ledges 10. The blades or wings form advantageously an angle of sixty to seventy degrees with the vertical line.

All wire nets, ropes, rings, and blades or wings may be covered with small metal needles which are electrically connected with each other.

From the space 11, formed between the double walls of the balloon, the pipe 26 leads from the lowest point of the same to the serpentine 12, arranged in the basket 6, which in turn is

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connected with the pipe 13, ending in the upper part of the space 11 between the two walls 1 2. The serpentine is heated by means of a suitable source of heat, whereby a warm current of gas or air circulates continually between the double walls of the balloon.

Under the basket the ball-bearing 14 is arranged in electrical connection with the wire nets, and its stud is electrically connected with the carefully-insulated light though sufficiently strong cable 15.

On the earth's surface is a winch 16, Fig. 2, by means of which the balloon can be made to ascend or descend as soon as the interior space of the balloon is filled with illuminating gas or hydrogen.

The end of the cable-core is soldered to a collector arranged upon and insulated from the axle of the winch, and the electricity is conducted from this collector by means of a sliding contact. The collecting of the electricity takes place by moving the balloon continuously up and down by means of the winch. In this movement the balloon is turned by means of the wings or blades 9, which are adapted to turn the balloon always in the same direction whether ascending or descending, as in the change from ascending into descending of the balloon, or vice versa, the blades are turned over by the aerial resistance, and thus impart the rotating motion to the balloon in the same direction. In order to avoid torsion of the cable, the ball-bearing 14 is provided. This up-and-down motion and rotating of the balloon accomplishes the purpose of bringing it into contact with as many water particles floating in the air as possible.

As the electricity conducted from the collector-wing 17 possesses a much too high and varying potential for making its direct application practicable, and as it is usual with an irregular source of electricity to first charge accumulators and to further utilize the easily-regulated current of the same only, it becomes necessary to seek to maintain the electricity conducted from the collector 17 for the charging of the accumulators at a constant potential and convert the potential to a much lower one; but as we deal in this case with a direct current ordinary converters cannot be used for this purpose. Moreover, the electricity possesses in this case a much too high potential, so that with the employment of ordinary converters the greatest part of the collected electricity would be lost again. The only practical method for this purpose is the converting by means of the Planté rheostatic machine, by which this high-voltage electricity can be transformed almost without any loss whatever. Thus the question of conversion would be solved, and only the question of maintenance of constant potential remains. This is obtained in the following manner: The rheostatic machine 18 or only a part of the plates is connected with an electrometer of any construction, the movable part of which closes a contact which eventually actuates an electromagnet which effects the switching or reversion of the rheostatic machine. After the switching of the rheostatic machine it is discharged, the potential falls to zero, (*nil*,) and the electrometer resumes its initial position, whereby the current of the electromagnet which effects the reversion is interrupted and the plates of the rheostatic machine are reconnected to potential. The machine is then ready for renewed charge and is again discharged when the determined potential is reached. This action is continually repeated as long as the apparatus is in operation.

A form of the automatic regulator for the rheostatic machine is represented in Fig. 4. 27 is the contact-cylinder of the rheostatic machine, on which, for clearness sake, only the contacts for the charging position of the condenser-plates are shown, while the contacts for the discharging position, which come into action after the contact-cylinder has been turned, are omitted. The coating of the condenser-plates is connected in electrical circuit with the stationary ball 29 and the movable ball 32 of the charge-meter 30. When the charge of the rheostatic machine rises, the ball 32, arranged on the one extremity of the lever 31, is repelled and at a certain stroke actuated by means of the fork 33, which is fastened on the ball 32, and by dipping into a mercury-cup it closes the circuit of the source of current 34. This current passes through the windings of the anchor or armature 35, fixed on the shaft of the contact-cylinder, and it also passes through the electromagnet 36. Thereby the contact-cylinder is turned by a certain angle and the rheostatic machine is thus reversed. Then if the tension decreases by discharge and the repulsion of the balls 29 32 declines so far that the contact is interrupted at 33 the spring 37 turns the contact-cylinder into its normal position and the rheostatic machine is again switched to tension. The regulation of the electrometer is effected by the adjustable weights 38 39. When larger quantities of electricity shall be derived or deviated, two rheostatic machines may operate alternately so, that while the one is being discharged the other can be charged. It is readily apparent that if the capacity of the rheostatic machine is not changed the switching or reversion by the electrometer will always take place at the same potential of the rheostatic machine, and as the number of plates, and hence the proportion of conversion, remains the same the current impulses derived or deviated from the rheostatic machine will also have the same potential.

The irregularities of the source of electricity change the interval of time in which the charges follow each other; but as long as the potential remains constant this has no injurious effect on the charge of the accumulators. The current derived or deviated from the

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rheostatic machine can be further transformed by an ordinary converter 21 22, and whenever it is sufficiently constant it can be utilized without the intervention of the accumulators. The converters can be connected or disconnected by means of the double switch 19 20 23.

24 and 25 are the conducting-wires, which run either directly to the place of consumption or to an accumulator-battery.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. An apparatus for collecting atmospheric electricity comprising a collecting-body adapted to be kept in motion, heating means for said body, and a rheostatic machine and a converter connected with the said body electrically, substantially as described.

2. An apparatus for collecting atmospheric electricity for storage comprising a collecting-body adapted to be kept in motion in the ambient air, heating means for said body, a conductor leading from said body, a rheostatic machine connected with the said conductor, an electrometer connected with said rheostatic machine electrically, a contact controlled by the electrometer, and an electromagnet controlled by said contact, said electromagnet controlling the reversing of the rheostatic machine, substantially as described.

3. In combination, the balloon-like collecting-body, having the collecting-points, means for heating the interior space of said body, a conductor leading from the balloon-like body, and electrical devices for receiving the current therefrom, substantially as described.

4. In combination, the balloon-like collecting-body, means for turning the same constantly in one direction in both ascending and descending, conducting means leading from the balloon and electrical devices for receiving the current therefrom, substantially as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

ANDOR PALENCSÁR.

Witnesses:
EUGÈNE HARRÄNJO,
PAUL BÖLESKEY.

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W. I. PENNOCK.

APPARATUS FOR COLLECTING ATMOSPHERIC ELECTRICITY.

APPLICATION FILED JUNE 26, 1907.

911,260. Patented Feb. 2, 1909.

Fig. 2.

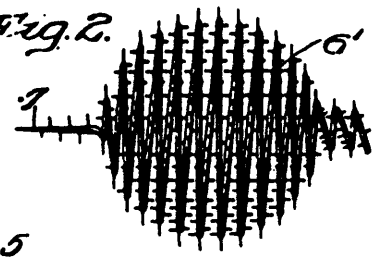
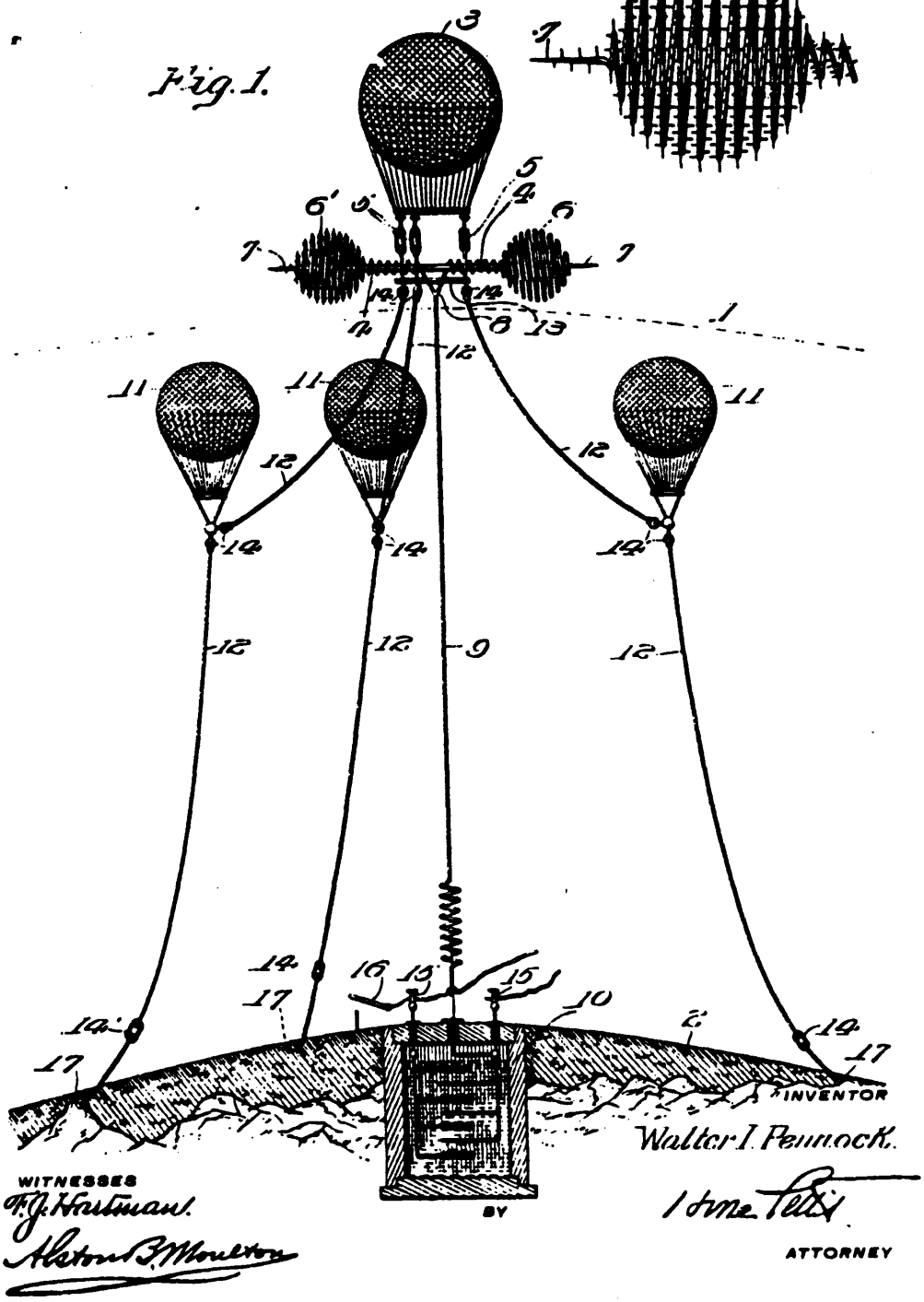


Fig. 1.



WITNESSES

F. J. Hastman.

Alston B. Moulton

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UNITED STATES PATENT OFFICE.

WALTER I. PENNOCK, OF PHILADELPHIA, PENNSYLVANIA.

APPARATUS FOR COLLECTING ATMOSPHERIC ELECTRICITY.

No. 911,260. Specification of Letters Patent. Patented Feb. 2, 1909.

Application filed June 26, 1907. Serial No. 380,907.

To all whom it may concern:

Be it known that I, WALTER I. PENNOCK, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Apparatus for Collecting Atmospheric Electricity, of which the following is a specification.

My invention relates to a method of collecting electricity from a strata laden with electricity at high altitudes in the atmosphere, through the medium of a wire cable suspended from one or more balloons and in conveying this electricity to the earth's surface.

The object of my invention is to provide a conveyance of the electro motive force to be found in the upper strata of the atmosphere to the earth's surface; where it may be utilized for commercial and other purposes.

A further object of my invention is to provide a device or mechanism by which a suitable collector for the electrical energy in the upper strata of the earth's atmosphere may be elevated in the said strata and by which the said electric energy may be transmitted to and collected at the earth's surface, from which point it may be conducted to any place where it is desired to use the same.

A further object of my invention is to support and anchor said device in any desired position.

A further object of my invention is to provide an improved form of collector through which the energy of the said upper strata of the earth's atmosphere may be collected and transmitted for various purposes to the earth's surface.

Other objects of my invention will appear in the specification and claims below.

For a further full, clear and complete disclosure of my invention, reference may be had to the following description and accompanying drawings, in which like reference characters refer to corresponding parts.

Figure 1 is an elevational view of one form or embodiment of my invention and Fig. 2 is a detailed view of one form of my improved collector.

The passage of the electrical current to the earth under ordinary conditions is prevented by an obstruction afforded by the dense lower strata of the atmosphere, which is a bad conductor of electricity, as shown by the electrodes of an ordinary static machine. When the electrodes are placed close together, the atmosphere is seen to carry the current across from one electrode to another, but if placed far apart the current is obstructed by the intervening air. The dense lower strata of the atmosphere affords one of the best non-conductors of electricity, as shown in the conduction of the electric current by telegraph, or trolley wires on the earth's surface, where only a small quantity of the electric current escapes through the atmosphere; while rarefied atmosphere affords a good conducting media, as shown by the vacuum tube. The upper strata of the atmosphere being rare in proportion to the altitude, and being a good conductor of electricity while the lower strata of the atmosphere being dense and affording a non-conducting media for the electric current, thus causes an obstruction to the electric current, or power in its passage to the earth's surface from the electric strata of the atmosphere under ordinary conditions. When, however, the cumulus clouds of a thunder storm pass over the surface of the earth, these clouds being of very great height, the moisture in said clouds forms a better conductor of electricity than does the dry air, with the result that the electricity in the upper strata of the atmosphere breaks through the said cloud as a streak of lightning and in that form reaches even to the earth's surface, while the thin or shallow strata of clouds, observed in the so-called "settled rain" storm, do not extend upward to a sufficient height to form a conducting medium for the electricity from the electric strata to the earth's surface. For this reason there is usually no lightning during the said latter variety of rain storm.

By means of my invention, I have provided a mechanism for collecting the electrical energy or power created by nature and stored in the upper strata of rarefied air of the earth's atmosphere and have provided a conductor for said electric energy to the earth's surface.

Referring now to the drawings 1 indicates what may be called the lower limits or boundaries of the strata of electric energy above the surface 2 of the earth.

3 indicates a balloon which is elevated to a high altitude until it enters the said stra-

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tum. The said balloon 3 carries a bar 4 of wood or any other suitable non-conducting material suspended by insulating links 5 or any other suitable form of insulation from the balloon 3. Upon either end of the said bar 4 I mount collectors, one form of which I have illustrated as spheres of coiled wire 6—6' the outer ends 7 of which terminate in sharp points. The inner turns of the said spheres 6 and 6' are wrapped around the wooden bar 4 and united as at 8 to a conductor of electric energy, preferably a large copper wire 9. This wire or conductor 9 extends to the earth's surface and may have its end suitably attached to an electric accumulator or other piece of electrical apparatus. I have illustrated one form of my invention in which the conductor 9 is connected to one pole of a storage battery 10 on the earth's surface.

The spiral spheres 6, 6' are preferably provided with a polished metallic surface to form a good conductor of electricity and the material of said spheres should also be of such a character that it will not rust or corrode or tarnish. A polished copper wire or a copper wire plated with platinum or gold or a solid platinum or gold wire may be used for this purpose, inasmuch as these materials are least affected by moisture and the atmosphere. The said spheres or collectors may be made of smooth wire as shown in the sphere designated by the numeral 6 or of barbed wire, as is shown at 6' and illustrated on a larger scale in Fig. 2 of the drawings. The latter form is preferable inasmuch as it provides a large number of points through which the electricity may flow to the wire from the surrounding air in the said upper strata of the earth's atmosphere.

In order that the supporting balloon 3 may be held in a relatively fixed position, it should be suitably anchored to the earth's surface. Inasmuch as the balloon 3 must be elevated to a very high position, the weight of the anchoring cables forms an important consideration, and if desired or necessary one or more supplemental balloons 11, 11, 11 may be attached to each of the anchoring cables 12, 12, 12 as illustrated in Fig. 1, to relieve the balloon 3 of such weight as would prevent it from ascending into the said electrical strath. In order that the electricity from the said upper strata of the earth's atmosphere may not be conducted down the anchoring cables 12, 12, 12, I attach them to the supporting balloon 3 and to the supplemental balloons 11 and to the earth's surface through suitable insulating devices 14.

In the form of my invention illustrated in Fig. 1, below the bar 4, I suspend a ring 13 of any suitable material from the balloon 3, and attach the anchoring cables 12 thereto by means of insulating rings 14, 14, 14. I may also provide additional insulating rings 14 between that portion of the anchoring cables 12 between the balloon 3 and the supplemental balloons 11, and also between that part of the cable 12 between the supplemental balloons 12 and the earth's surface. I may also provide, near the earth's surface and at the lower end of the anchoring cables 12, similar insulating links 14. While I have described links as forming a convenient form of insulating device for the purposes above set forth, I do not wish to be construed as being limited to the same, inasmuch as any suitable non-conducting connection may be used in place of the links 14.

The terminals 15, 15 of the storage battery 10 may be connected to any piece of electric apparatus which it is desired to run or operate and if desirable one of the poles of the battery is adapted to be connected by the switch 16 with the earth's surface. The lower ends of the anchoring cables 12 are securely anchored to the earth's surface as at 17.

With the apparatus arranged and connected in the manner illustrated in Fig. 1, the electric energy in the high strata of the earth's atmosphere passes to and through the conductive spiral spheres 6 or 6' to the conductor 9 and is suitably stored or used at the earth's surface, while the balloons 11 support a part of the weight of the anchoring cables 12, and permit the balloon 3 to ascend as high as is possible, or necessary for it to enter the said electrical strata of the earth's atmosphere. By arranging the anchorage 17 of the cables 12 symmetrically or in any other position than in a straight line, the balloon 3 may be held in a substantially fixed position with relation to the earth.

While I have illustrated in the drawings and have described in the specification a form of apparatus in which my invention may be carried out, it is obvious that the drawings are more or less diagrammatic drawings, that is to say, that the proportions of the various parts are not necessarily those which would operate to the best advantage, inasmuch as certain portions have been shown as greatly enlarged in the drawings for the sake of clearness, and that it is likely that more than one supplemental balloon would be requird for each cable in order to support the weight of the same, and to relieve the supporting balloon 3 of such weight, as would prevent it from ascending into the high electrical strata of the earth's atmosphere, but such changes in form, proportion and arrangement I regard as being fully within the aim and scope of my invention, so long as such forms or modifications fall within the scope of the append-

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ed claims. It is also to be understood that the storage battery or accumulator which I have shown as being connected to my collector, is only a type of apparatus which can be operated by the current collected by the spheres 6, 6' and transmitted to the earth through the wire 9_2 and when I use the word "accumulator", I mean any piece of useful apparatus which is operated by the current transmitted thereto through the wire or conductor 9.

Having thus described my invention, what I claim and desire to protect by Letters Patent of the United States is:

1. The combination with an electrical collector comprising a bar of non-conducting material, and an open spherical conductor carried by said bar, of means to support said collector in the high electrical strata of the earth's atmosphere.

2. The combination with a balloon, of an electrical collector supported thereby and insulated therefrom, comprising a bar of non-conducting material, and a conductor wound spirally around said bar.

3. The combination with an electrical collector comprising a non-conducting bar, and a conductive wire wound thereon to form an open substantially spherical body, and means to support said collector in the high electrical strata of the earth's atmosphere.

4. The combination with a balloon, of an electrical collector carried thereby and comprising a non-conducting bar, and a polished wire wound spirally thereon to form an open substantially spherical body.

5. The combination with an electrical collector comprising a non-conducting bar, and a wire wound spirally thereon to form an open substantially spherical body, said wire being provided with pointed conducting projections, and means to support said collector in the high electrical strata of the earth's atmosphere.

6. The combination with a balloon, of an electrical collector carried thereby comprising a non-conducting bar, and a conducting wire wound spirally thereon to form open substantially spherical bodies upon the opposite ends thereof.

7. The combination with a balloon, of an electrical collector carried thereby comprising a non-conducting bar, a conducting wire wound spirally thereon to form open substantially spherical bodies upon the opposite ends thereof, an electrical accumulator, and an electrical connection between the said collector and said accumulator.

8. The combination with a balloon, and means to anchor said balloon, of an electrical collector supported by said balloon and insulated therefrom, an electrical accumulator, and a conductor connecting said collector and said accumulator.

9. The combination of an electrical collector, means to support said collector at a high elevation from the earth's surface and within the electrical strata of the earth's atmosphere, an electrical accumulator at the earth's surface, an electrical connection between said collector and said accumulator, and means to insulate said supporting means from said collector and from the earth.

In testimony whereof, I have hereunto set my hand this 25th day of June, 1907.

WALTER I. PENNOCK.

Witnesses:
HUGH F. QUINN,
WM. G. GLENN.

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SECTION 4

VRILLIC DETRITUS

ON THE ELECTRICAL CURRENTS OF THE EARTH.

By Charles Matteucci.

TRANSLATED FOR THE SMITHSONIAN INSTITUTION.

The study of electric currents in the terrestrial strata dates, I think, from the discovery of the galvanometer. M. Fox, in England, was the first who saw the needle deviate when different points of a metallic vein were touched with the extremities of the wire of the galvanometer. M. Becquerel afterwards made very extensive researches on electric currents obtained between masses of water and strata of earth existing under different conditions. Till then these experiments were regarded but as obscure cases of electro-chemical action, of difficult interpretation. There was no thought, in this case, of any such thing as a terrestrial phenomenon—that is to say, of *spontaneous* electric currents, as they are called by the celebrated astronomer of Greenwich—until very strong electrical currents had been observed in telegraphic wires during the appearance of the aurora borealis. This phenomenon presented itself for the first time, November 17, 1847, in the telegraphic wires of Tuscany, while a bright aurora was visible on the horizon. The description of this phenomenon, which I gave to the French Academy in a letter addressed to M. Arago, was followed shortly afterwards by similar observations made in the United States. In late years numerous observations have been made on this subject on all telegraphic lines, and have confirmed the first results. It was natural to seek the existence of electric currents and their laws in telegraphic wires, independent of the simultaneous appearance of the aurora borealis, and the Academy of Sciences is cognizant of the researches on this subject which have been made public by such eminent savants as MM. Baumgarton, Barlow, Lloyd, and Walker. When their memoirs are read with the attention they merit, no one can fail to be struck with the difficulty which presents itself in harmonizing the results they have obtained and deducing some general consequence which might set us in the way of explaining these phenomena. All these researches have been conducted by introducing a galvanometer into telegraphic lines, and measuring the currents at such times as the lines were not in service for the transmission of despatches. Ordinary communications, established as telegraphic stations between the metallic wires and the earth, are effected, we know, in different ways; sometimes they are formed by plates of iron or copper plunged into the water of wells more or less deep, and connected with the metallic wires; sometimes these wires communicate with the shafts of pumps or with the rails of an iron road. With the exception of the distinguished astronomer of Munich, who seems, especially in his later experiments, to have duly considered the necessity of guarding against currents excited by the extremities of the lines in communication with the earth, the observers have given us no intimation how these communications were established.

Yet it is not difficult to discover on any telegraphic line taken at hazard that the currents obtained in these lines depend on the heterogeneousness of the plates which communicate with the earth. I have often seen these currents

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undergo a change of sign when the position of the plates was changed or their heterogeneousness was modified by causing the current of a battery to pass in a given direction. These currents disappear, or are considerably weakened, by employing plates and liquids as homogeneous as possible. By employing more sensitive galvanometers and quite homogeneous plates of copper, it will readily be recognized that the slightest difference in the composition of the water of the terminal wells suffices to excite currents. It need scarcely be added that in operating upon telegraphic lines, it is necessary to take account of the secondary polarities which the currents of the battery develop, sometimes in one direction, sometimes in the other. Telegraphic lines have also other causes of error due to the variable contact of the wire with the posts. From the moment when I proposed to study this subject, I felt convinced that, before aught else, it was necessary to possess a method by which would be realized the condition of having long conducting wires, perfectly isolated, extended in definite directions, the communications of which with the earth should be absolutely homogeneous, and which should form mixed circuits, all endowed with the same conductibility. It was in the following manner that I attained these objects:

The wire which I employed was of copper, two millimetres in diameter, and covered with gutta-percha; this wire was suspended by means of a sort of cleft, wrought in the top of a rod or slender post of wood, such as is in use here for military telegraphic lines. These wooden rods were planted at a distance of 25 or 30 metres from one another, in two lines exactly traced, one in the magnetic meridian, the other perpendicular to the meridian. Each of these lines was six kilometres in length, the place where they were established being the plain of Saint Maurice, 22 kilometres from Turin, a plain set apart for military exercises. The communications between the extremities of the wire and the earth were effected in the following manner. At the extremity of each line I caused to be dug a kind of pit of rectangular form, two metres in depth and length, and one in breadth; at the bottom of this pit was formed a cavity much smaller, and which might be termed a sort of capsule, having a width and depth of 30 centimetres. A bed of clay, such as is used in the fabrication of pottery, was carefully spread over the interior surface of this capsule, so as to prevent the water from percolating too rapidly through its wall. The same water, being that from a river, was employed for the four cavities, and the person appointed to superintend at each extremity had a supply of this water at hand, in order to maintain it constantly at the same level. Lastly, a porous cylinder, such as is used for the batteries of Daniell, filled with a saturated and neutral solution of the sulphate of zinc, was plunged in the water at the centre of the cavity, and the wire of the line was united to a plate of zinc perfectly amalgamated, and which in turn descended into the solution of the sulphate. The porous cylinders thus prepared and the plates employed were tested in advance, and this testing was renewed from time to time, so as to be sure that the plates were perfectly homogeneous. It rarely happens that two plates once rendered properly homogeneous undergo alteration for several days when they remain constantly immersed in the solution. Should, however, a slight heterogeneity appear, it will suffice to wash and amalgamate them anew, in order to render them again homogeneous. The two lines also must be ascertained in advance to have the same conductibility. In a uniform plain, like that in which I operated, the pits being excavated in nearly the same stratum, the differences of conductibility could not be great; but I succeeded in rendering them equal by deepening by a few centimetres the cavities made at the bottom of the pits of that line which was found to be most resistant.

In this manner the conditions of the circuit which I deem essential for these experiments were realized. It is proper to remark that, wishing to test in advance two similar excavations, with cavities at the bottom as above described, and formed at a distance of five to six meters from one another, I found no trace of

current between these cavities, as I had obtained none in employing the two porous cylinders with their plates of zinc plunged in a vat filled with water. I proposed also to test beforehand whether the nature of the formations in which the pits were excavated might have some influence. With this view I caused the earth proceeding from the excavation of pits near the place where I was established to be transported, and two cavities formed in a neighboring field to be filled with it; having then introduced into this earth, in the manner already described, the extremities of the galvanometer, I obtained no sign of a current.

Very near the place where the two lines, north-south and east-west, crossed one another, each of the lines was interrupted, and the extremities thus obtained were passed into two capsules filled with mercury in the chamber where I had stationed myself with the galvanometer. I employed alternately three galvanometers—one of 1,500 coils, another of 100, and a third of 24,000 coils; the numbers which I shall report in my memoir were obtained with the first of them.

I must be excused for these long details on the process which I employed; I have thought it necessary to give them, as well by reason of the importance of such researches as of the difficulties and uncertainty met with in the investigations which I have before cited. I continued the experiments on the two lines for nearly a month, from the 12th or 15th of March to the 15th of April of the present year, during which time the weather was generally fair, the air cold and dry, the sun very warm. I cannot report in this abstract all the numbers obtained in this long series of experiments; for ten days the observations were made almost hour by hour, with a change of observers. I am compelled, therefore, to give here only a recapitulation of the results at which I have arrived.

1. In two circuits, formed in the manner which I have described, it is rare not to find electric currents more or less constant, whose origin cannot be attributed absolutely to the heterogeneousness of the terminal metallic plates, nor to chemical action between the water in which the plates are immersed and the terrestrial strata.

2. These currents augment in intensity by deepening the cavities into which the terminal plates are plunged from $0^{m}.50$ to 2 metres; the greater conductibility found in the mixed line by deepening the terminal cavities accounts for this result. The same may be said of the slight and transient augmentation of the electric currents which is realized by the effect of rain on the earth immediately surrounding the cavities in which the electrodes are plunged.

3. It has not been found that the extent of the plates of zinc and the diameter of the porous vessels have a distinctly marked influence on the intensity of these currents, when operating at a depth of two metres.

4. In the meridian or south-north line, the current has always maintained a constant direction; hundreds of observations have continually shown that the current entered the galvanometer by the metallic line coming from the south, and issued from it through the line directed to the north. By comparing the very nearly conformable deviations obtained in this great number of observations, it would appear that this current presents in the 24 hours two *maximums* and two *minimums* of intensity. The two minimums occur during the day and in the night, at nearly the same hours, that is from 11 to 1 o'clock. After 1 o'clock in the night, the current augments and attains a maximum at from 5 to 7 o'clock in the morning. In the day this maximum oscillates between 3 and 7 o'clock in the afternoon. The difference of intensity between the maximums and the minimums of intensity is greater than that of 1 to 2.

5. In the equatorial line the results are very different, and subject to great variations. Frequently the needle rests at 0°, frequently it oscillates, sometimes into one quadrant, sometimes into the other, ranging from two to three degrees, and even 14° and 15° on the same side, and often oscillating around 0°. The direction of these currents, which has occurred most frequently in the equatorial line, was from west to east.

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6. By establishing communications between the lines south-east, south-west, and north-east, north-west, the currents realized were generally those which circulated in the portion of the line pertaining to the south-north line.

7. Only the temperature more or less elevated, which varied from 0° at night to + 14° or 20° by day, was ever observed; the humidity or dryness of the air, and even stormy weather, had an influence on the direction and intensity of the current of the meridian line.

8. The results have been the same, whether the metallic portion of the line was suspended on posts or laid upon the surface of the ground.

What is the origin of these currents? I believe it impossible to answer this question with any confidence. What ought to be considered as perfectly proved by experiment is, that in a wire, when it reaches a certain length and its extremities are in good communication with the earth, there is an electric current which constantly circulates, and principally in the direction of the magnetic meridian; the origin of this current is neither in the metallic part of the circuit, nor in the terminal metallic plates, nor in any chemical action which might be surmised between the terrestrial strata and these plates, or the liquids in which they are immersed.

Should these currents be considered as derived currents? I have heretofore demonstrated, what every one at present admits, and which is accordant with theory, that the resistance of a terrestrial stratum is very nearly null and does not vary with the length of that stratum. These considerations are not favorable to the idea that the currents we have described are derived currents. On the plain of Saint Maurice, I have made some experiments to ascertain to what distance from the electrodes of the battery derived currents were sensible. I used for extremities of the derived circuit the same plates of zinc plunged in the saturated solution of the sulphate of zinc which have been described above. The circuit of the pile was six kilometres in length; its extremities consisted of square plates of copper, 20 centimetres to the side, immersed in water to the depth of two metres. The battery was composed of 20 elements of Daniell; the galvanometer of the derived circuit was that of 1,500 coils, before mentioned. When each of the electrodes of the derived circuit was at a distance of 10 metres from the electrodes of the battery, in a straight line between these electrodes, I obtained a steady derived current of 33°; this deviation remained constant during the whole time that the current of the battery did not vary, that is for several hours. On increasing, to 50 metres, the distance between the electrodes of the battery and those of the derived circuit, there were 4° of derived current; at 100 metres this deviation was barely half a degree; and at a distance of 200 metres, it is doubtful whether there was any movement at all in the galvanometer at the closing of the circuit of the battery. It seems to me difficult to derive from these experiments any satisfactory reply as to the nature of the electric currents observed in long mixed lines.

General Sabine, the highest authority of the present day in point of terrestrial magnetism, appears to admit absolutely the magnetic influence of the sun upon the earth. But, if this influence be admitted, what explanation can be given of the currents we obtained and the differences of those currents according as the line is in the meridian or perpendicular to it, or the periods of intensity in the former of these lines? Assuredly these currents cannot be currents of induction due to the rotation of the earth. It is stated that Father Secchi, the indefatigable astronomer of Rome, is occupied at this time in investigating the connection which exists between the electric currents of long mixed lines and the variations observed in the instruments which measure the magnetic force of the earth. If a connection of this kind were well established, we should certainly have taken a step towards the interpretation of the electric phenomena of the earth.

It remains to report a result which has some importance, and which I have constantly realized: These terrestrial currents have a greater intensity, in the

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case of a mixed line, when, the distance between the extremities remaining the same, the terminal cavities which constitute the communication between the wires and the earth are at different levels, than when these communications are established in a horizontal plane. For the verification of this, I have established on the heights of Turin a line whose wire, in a straight direction, has a length of scarcely 600 metres, while the terminal cavities have a difference of level of nearly 150 metres. The line which joins the two cavities is in an intermediate direction, or southeast and northwest. The current has circulated constantly, for five or six months, from below upwards in the wire, or from the northwest to the southwest extremity. All the precautions which I have before described were observed in the construction of the cavities in which the plates of zinc are sunk, and I am certain that the current obtained depends neither on any heterogeneousness in the wire, nor on the terminal plates, nor on a chemical action between the plates and the terrestrial strata in which they are imbedded. When care is taken, as I have practiced for several days in succession, to maintain at a constant height the liquids of the terminal cavities, that is to say, the water and the solution of sulphate in the porous vessels, the deviation remains nearly invariable, whatever may be the state of the sky and temperature of the air, and only after quite a long rain has the deviation temporarily increased. In this line I have not remarked the periods of which I have spoken. Other lines of nearly the same length, established in similar formations at the foot of the hill on a horizontal plane, yielded no sensible deviation.

If the influence of the difference of level of the extremities of the metallic line should be verified in a great number of different cases, if the direction of the current in the wire should prove constant, that is to say, always from below upwards, might we not be tempted to attribute these currents to the negative electric state of the earth, the tension of which is then unequal between the plain and the elevated points, as we find in an electrified globe communicating with a metallic point? As the signs of the positive electricity of the air are seen in effect to augment in proportion as we ascend in the atmosphere, so also are the signs of negative electricity found to be stronger in ascending, when an isolated copper wire, one extremity of which communicates with the earth, is carried with the other extremity in contact with the ball of the electroscope. This explanation might be submitted to proof when the atmosphere presents for a certain time signs of negative electricity. I have sometimes obtained very transient signs of this electricity at the approach of storms of rain, without noticing any variation in the current of the line.

My chief object has been to investigate the relation which exists between these currents and atmospheric electricity, and next, to verify the result obtained and described in the first part of this memoir, by studying these currents in lines, the extremities of which are sunk in the earth at different levels. The first experiments were made upon the line above described, between the hill of Turin and the adjacent plain. The extremities, as has been already said, were terminated by plates of amalgamated zinc immersed in a saturated solution of sulphate of zinc contained in a porous vessel, which was plunged in turn in the water of a sort of capsule excavated from one to two metres below the surface of the earth. This mode of constructing the mixed* line is the only one which yields sure and constant results, and I would advise all physicists who occupy themselves with the subject not to deviate from it. The water which filled the two cavities was the same, and care was taken to maintain it at a constant level. During several days of July, in the present year, I have continued to observe from hour to hour the deviations of the galvanometer inserted in this line; the current was always an ascending one in the wire, though I changed several times the position and

* By this term we understand a circuit composed of an extended wire and the strata of earth intervening between its extremities.—*J. H.*

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the ground in which the terminal cavities were dug, and the deviation was not found to vary in a lapse of many days, provided there was neither tempest nor rain. After rain, the deviation was constantly seen to increase. I have satisfied myself, by measuring a constant current transmitted in this mixed circuit, that the augmentation which followed rain was only the effect of the better conductibility of the earth depending on a state of greater humidity in the terrestrial stratum immediately in contact with the extremities of the line. And, in fact, it could be obtained by pouring around the cavity in which the electrodes were plunged, within a radius of two to three metres, a few buckets of water.

I have tried the immersion of the electrodes in the water of a well, which was effected by a very simple contrivance. For this purpose, I take a thick square piece of cork and fix, in a hole made in this cork, porous vessels filled with sulphate of zinc. The cork suspended by a cord floats on the water of the well into which the porous vessels descend; by means of a copper wire covered with gutta-percha and bound to the cord, the electrode of zinc was introduced into the porous vessel and communicated with the line. I was thus able to establish the mixed line, employing the well water as extremities of the terrestrial stratum, in which the electrodes were sunk. With this arrangement, also, I have realized an ascending current in the wire, and the deviation was only a few degrees greater than that of the current obtained by using the artificial cavities or pits which I have described above. By using the wells we have this advantage: that the conditions of conductibility of the terrestrial strata into which the electrodes are introduced remain invariable. It is necessary to ascertain in advance that the waters of the two wells, when those which we employ are in two cavities formed in the earth at a short distance from one another, do not yield an electric current. I have varied as far as possible the excavations situated at different levels, but in all cases have found the current in the metallic line to be an ascending one. I was even enabled to divide the line at the hill of Turin, a length of nearly 600 metres, about midway where there existed a well, and this remarkable and constant result was realized: that, notwithstanding the greater resistance of the entire line, the current, which continued to be ascendant in the two halves, had still a less intensity in the two lines taken separately than in the entire line.

I have had an opportunity of observing in these lines the effects of two or three storms during the month of July. I will first remark, that I have satisfied myself that in leaving one of the extremities of the line in communication with the electrode and the earth, and the other in the air, I had never any trace of a current, even when using a galvanometer of 24,000 coils. I have often made the experiment of putting an isolated metallic vessel, at the end of a wooden staff from seven to eight metres high, in communication with the extremity of the line which was in the air; placing in the vessel sometimes lighted coals, sometimes touch-wood, sometimes shavings saturated with burning alcohol, in order to obtain a large flame and a current of heated air. In all these experiments, whichever might be the extremity of the line immersed in the water or raised in the air, I have never obtained a sign of the current in the most delicate galvanometer, provided care were observed to isolate the line effectually and no account were taken of the indications of the galvanometer at the moment when it was necessary to touch the line with the hands.

Neither, during storms, have I observed, with the line, which was only 600 metres in length, any deviation in the needle at the moment when lightning flashed between clouds, provided the two extremities of the line are not in communication with the ground. When this communication is established and a deviation of the needle has resulted from the terrestrial current, a sudden movement is seen to take place at each flash, such as would be occasioned by the discharge of the torpedo fish. I observed at the same time the galvanometer and an electroscope of dry batteries *(à piles sèches)* communicating with an iron wire from seven to eight metres long, well isolated and raised in the air, and having

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a piece of lighted touch-wood at the upper extremity. Most frequently the electroscope gave signs more or less strong of positive electricity, which augmented suddenly at the moment of the flash. At the same instant the needle of the galvanometer made a deviation of at least 15° to 20°. This sudden deviation was always in the same direction, indicating an ascending current in the wire, and was additional to the terrestrial current. It should be remarked that I have had the opportunity of making this observation in a case in which, on account of plates of copper being employed as electrodes, the current of the line was contrary to the terrestrial current which is constantly obtained with electrodes of zinc.

Thus, then, the ascending current in the wire whose extremities are sunk in cavities which have a difference of level of about 150 metres, and which, from the manner of operating, must be regarded as a terrestrial current independent of the chemical actions of the electrodes and the strata of the earth—this current, I say, augments suddenly at the moment when there is an electric discharge between clouds. There remains here an important observation to be made, in which, as yet, I have not been able to succeed: to notice, namely, what would happen when the atmospheric electricity is negative.

I have deemed it of some importance for the theory of these phenomena to substitute for the iron wire suspended on bells of porcelain, a copper wire covered with gutta-percha laid upon the earth and buried as much as possible in the grass and under the leaves. None of the phenomena before described in the suspended line, whether with a clear sky or during storms, have been modified by this change of the metallic line. We can conceive that during the flash of lightning, at the moment when an electrified cloud, which had acted by influence on the points of the ground placed within its sphere of action, discharges itself and suddenly ceases to act, a sudden neutralization may take place in the conducting wire, producing the electrical effect noticed with the galvanometer.

It remains for me to report the results I have obtained by operating on telegraphic lines of great length and whose extremities were at a great difference of level. I employed the same galvanometer and the same process of communication for the extremities of the line with the earth, that is to say, plates of amalgamated zinc, immersed in sulphate of zinc, contained in porous vessels floating on the water in the manner I have described. I have made three series of experiments, one on the telegraphic line from Ivrée to Saint Vincent, in the valley of Aosta, 36 kilometres in length, and in which the difference of level of the extremities was 281 metres. The second series was made on the line from Saint Vincent to Aosta, 25 kilometres long, the difference of level of the extremities being 83 metres. The third line, 27 kilometres in length, passed from Aosta to Courmajeur, at the extremity of the valley, and the difference of level of the two extremities was 642 metres. The electrodes of zinc were sunk in cavities dug in the ground to the depth of about half a metre. These cavities I caused to be filled with the whitish water proceeding from the glaciers, which flows in great abundance in the valley; being that which, under the circumstances, might be considered as having in every respect the same composition. I should state that the line from Ivrée to Saint Vincent is nearly parallel to the meridian, while the other, from Saint Vincent to Courmajeur, intersects the former almost perpendicularly.

The following were the results obtained. The electric currents in these three lines, notwithstanding the much greater resistance in comparison with the line of 600 metres on which I had previously operated, were stronger; as were also the regular deviations, so as to rise from 40° to 60°, and even 80°, instead of 20° and 25°, which I had realized on the hill of Turin. The experiments were made at very different hours, but the regular deviation indicated in every case an *ascending* current in the wire, as in the experiments on the line of the hill just mentioned. In the greater number of cases, the deviation of the needle

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remained at the same angle during the whole experiment, which sometimes continued for an hour; but I have observed also, without any change having occurred in the state of the sky, a movement in the needle almost periodic. Twice I have seen the needle deviate at first by an ascending current, and after some minutes descend to zero, then pass into the opposite quadrant and return afterwards to the previous deviation, becoming eventually fixed under the action of the current ascending in the wire. It has seemed to me that this phenomenon was presented when the water which filled the cavities of the electrodes was in movement and flowed rapidly away around the porous vessels. Reflection on the conditions under which we are compelled to operate in this sort of experiments, will suffice to evince the difficulty of solving all the doubts which may present themselves in the prosecution of our inquiries.

Notwithstanding the difficulties inherent in such researches, and which impose on the physicist the greatest reserve in his conclusions, we may regard, I think, the following results as founded on a large number of facts conformable with one another and obtained under different circumstances:

When a metallic line is stretched upon the earth, but isolated from it, while the extremities of the wire communicate with the earth at two points having a different elevation, an electric current circulates constantly in the wire, the cause of which current can be attributed neither to the chemical action of the electrodes, nor to that of the terrestrial strata in which they are sunk.

This current is constantly directed in the wire from the lowest towards the highest point, and its intensity is greater in the longer lines and as the difference of level of the extremities is more considerable.

The intensity of this current does not vary sensibly with the depth of the cavities in which the electrodes are sunk, and is the same in the wire suspended at some metres from the ground as in that which is in contact with it.

Two circumstances present themselves as constantly associated with this phenomenon, circumstances which, by their analogies, may assist in explaining it; I mean the difference of temperature of the two extreme points and the difference of electric tension of these points. I shall only remark here that I could cite results in which the influence of difference of temperature could not be considered as cause of this phenomenon, which to me appears to be due to terrestrial electricity.

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OBSERVATIONS ON THE ELECTRIC RESONANCE (BOURDONNEMENT) OF MOUNTAINS.*

BY M. HENRI DE SAUSSURE.

[*Translated for the Smithsonian Institution.*]

Leaving Saint-Moritz (Grisons) June 22, 1865, I made an ascension of the Piz Surley, a mountain composed of crystalline rocks, whose summit, more or less conic, attains an altitude of 3,200 meters.

During the previous days the north wind had constantly prevailed; on the 22d the wind became variable, and the sky was charged with floating clouds. Towards midday these vapors augmented and gathered in masses above the highest summits, sustaining themselves, however, at such an elevation as not to veil most of the spires and peaks of the Engadine, on which fell soon some local showers. Their aspect of *powdery vapors*, semi-transparent, caused us to take them for mere squalls of snow or sleet.

In effect, towards one in the afternoon, we were ourselves assailed by a fine and thin sleet, at the same time that similar squalls enveloped most of the spires of rock, such as the Piz Ot, Piz Julier, Piz Langard, &c., and the snowy summits of the Bernina, while a voilent fall of rain descended on the valley of Saint-Moritz.

The cold increased, and half an hour later, when we had arrived at the top of the Piz Surley, the fall of sleet becoming more abundant, we disposed ourselves to take a repast, and leaned our staves against a small pyramid of dry stones which crowns the summit of the mountain. Almost at the same instant I experienced in the back, at the left shoulder, a piercing pain, like that which would be produced by a pin slowly driven into the flesh, and when I applied the hand to the place without finding anything there, similar pain was felt in the right shoulder. Supposing that my linen overcoat contained pins, I threw it off; but, far from finding relief, I perceived that the pains augmented, invading the whole back from shoulder to shoulder; they were accompanied by tickling, by distressing twinges, such as would be produced by a wasp which was creeping over the skin and piercing me with stings. Hastily removing my second coat, I discovered nothing of a nature to wound the flesh. The pain, which still continued, then assumed the character of a burn. Without reflecting, I imagined that my woolen shirt, though I could not tell how, had taken fire, and I was going to throw off the rest of my apparel, when our attention was attracted by a noise which resembled the humming of large insects. This proceeded from our three staves, which, inclined against the rock, were *chanting* loudly, giving out a whistling sound analogous to that of a kettle, the water of which is on the point of entering into ebullition. All this may have occupied four or five minutes.

I comprehended, on the instant, that my painful sensations proceeded from an intense electrical efflux which was taking place from the summit of the mountain. Some extemporized experiments on our staves yielded no appearance of any spark nor any light appreciable by day; they vibrated with force in the hand

*The observations which follow had been communicated by correspondence to M. J. Fournet, who has introduced them in his notices on *Electric Regions*, published in the *Comptes Rendus de l'Académie des Sciences*, tome xliv, 1867. We give them here with some modifications and considered in a more special point of view.

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and gave a very distinct sound; whether held in a vertical position, with the iron point above or below, or in a horizontal one, the vibrations remained the same, but no sound escaped from the surface of the ground.

The sky had become gray over its whole extent, although unequally charged with clouds. Some minutes afterwards I felt the hairs of my head and face stand on end, imparting a sensation analogous to that of a razor passed when dry through a stiff beard. A young Frenchman, who accompanied me, exclaimed that he felt a sensation in every particular hair of his incipient moustache, and that strong currents were issuing from the tips of his ears. On lifting my hand I felt currents quite as distinctly escaping from my fingers. In short, a strong electricity was flowing from staves, clothes, ears, hair, and from all the salient parts of our bodies.

A single explosion of thunder was now heard towards the west in the distance. We quitted the peak of the mountain with some precipitation, and descended about 100 meters. In proportion as we proceeded our staves vibrated less and less strongly, and we stopped when their sound had become so feeble as to be no longer perceptible except on bringing them close to the ear. The pain in the back had ceased with the first steps of the descent, but I still retained a certain vague impression of it.

Ten minutes after the first, a second reverberation of thunder was heard to the west at a great distance, and these were all. No lightning was seen. Half an hour after we had left the summit the sleet had ceased, the clouds broke away, and at 30 minutes after two we again reached the topmost point of the Piz Surley, there to find sunshine.

We judged that the same phenomenon must have been produced on all the peaks formed by projecting rocks, for all, like that which we occupied, were enveloped in whirls of sleet, while no condensation showed itself in the rest of the sky; and the great snowy summits of the Bernina, to which clung groups of clouds, seemed also exempt from it. But, the same day, a violent storm burst upon the Bernese Alps, where an English lady was struck by lightning. On the horizon, divers peaks, especially the sharpest, such as the Piz Ot and the Piz Languard, continued to be enveloped by sleety whirls, even when the sky had everywhere begun to grow blue.

I had been the witness of another case of the efflux of electricity from the summit of mountains when I visited, some years ago, the Nevado de Toluca, in Mexico; but there the phenomenon had still more intensity, as might be expected, since it occurred under the tropics, at an altitude of about 4,500 meters. I may be allowed to cite here what I have elsewhere said of it.*

In the month of August, 1856, I made, with M. Peyrot, the ascent of the Nevado de Toluca; it was in the midst of the rainy season, and there was some degree of imprudence in attempting the expedition at that time. We attained the summit without any menacing appearance of the skies, though cumuli were to be seen here and there, and from time to time fogs settled on the needles of rocks which spring aloft from the crest of the mountain. We rested on the border of the crater to recover our strength and enjoy for a moment the grand spectacle which unfolded itself at our feet. From the height of the edge the eye plunged into that immense amphitheater, whose focus, long extinct, is now occupied by two small lakes, towards which we were preparing to descend. A cold and disagreeable wind arose from this gulf, and, while we were taking a slight repast, we saw a thick cloud penetrate into the crater by its southeast notch and ascend towards us, eddying around the walls of the amphitheater. Presently we were enveloped in a glacial fog. Surprised by this threatening symptom, we saw that we had not an instant to lose if we wished to visit the crater, and I commenced clambering down over the rubbish which leads to the

* *Coup d'œil sur l'hydrologie du Mexique*, 1 part, (note. A)

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bottom of the abyss. But scarcely had I reached half way when the storm, bursting forth with astonishing suddenness, obliged me to reascend as soon as possible towards the point I had left.

There was at first a fine rain, then small hail, driven by a violent wind. In a moment the mountain became white and the cold intense. The bursts of thunder, at first interrupted, soon seemed to roll without cessation and with fearful crashes, especially when they issued from the circuit of the crater, into which darted, at frequent intervals, flashes of lightning. Without shelter in the midst of these naked rocks, without even a block behind which to cower, nothing remained for us but to sit down on the earth with backs turned to the hail. After the lapse of some time the cold became insupportable, and the dread with which the tempest had inspired us drove us from the summit, though our observations were unfinished. While we descended rapidly the rocks of the Nevado, rain for an instant succeeded the hail, and as we coasted a small stony ravine,* formed by ancient outcrops of trachyte, and where the vegetation of shrubs commences, the storm seemed momentarily to subside. The thunder ceased or drew off to a distance, but we presently saw a grayish cloud advance, which enveloped us during its passage, and *was accompanied with sleet*. Immediately the hair of our Indian attendants was observed to be in agitation as if about to stand erect, and we experienced various electrical sensations in the beard and ears. Next a dull, undefinable noise was heard, at first feeble though general, but presently stronger and perfectly distinct. There was a universal crepitation, as though the small stones of the whole mountain were clashing against one another. Our terrified Indians gave free vent to their superstition in words, and it cannot be denied that there was something disquieting in the sounds which then prevailed in the mountain. This phenomenon lasted five or six minutes, and then the rain and thunder again commenced in full force. The storm became more supportable when we had descended to the upper limit of the forests, although one of those diluvial rains was falling which characterize the hot season under the tropics.

M. F. Craveri, an Italian physicist, settled at Mexico, who, before myself, had made an ascent of the Nevado de Toluca at the commencement of the rainy season, recounted to me that he had been a witness of the same facts, which he could not recall without an impression of terror. The electric state was still more violent. The traveler in question ascended the mountain May 19, 1845, by the southeast side, starting from Tenango, and descended by the northwest slope to Toluca. The southwest side was at that season destitute of snow. The electric phenomenon was suddenly brought on by a cloud arriving from the west, and which had perhaps taken its rise on the fields of snow of that side. Scarcely were the travelers enveloped in it when they experienced the sensation which electricity produces, and this was almost immediately followed by a dull noise. They felt irregular currents of electricity at all their extremities, the fingers, the ears, the nose. The fear which seized them in the midst of these lofty solitudes impelled them at once to commence their descent at a precipitate pace. The thunder did not yet resound, but at the end of five minutes *there fell a snow resembling rice*, and the cloud communicating its electricity to the ground, the same noise arose therefrom which I have indicated above. This noise was very intense and seemed general in all the mountain. The long hair of the Indians became stiff and erect, giving to their heads an enormous magnitude. The sight of this phenomenon added to the panic terrors of the excursionists, who had counted upon finding nothing but pleasure in the adventure.

The very singular noise which makes itself heard in the rocks of the mountains at the moment of the electric phenomenon deserves to be studied by competent physicists. It resembles the rattling sound which pebbles would produce if

* For greater precision I have modified this passage, having written in my former notice: "as we followed a stony valley." There was, in fact, but a slight depression of the soil, whence the word "valley" says too much and might be misunderstood.

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struck against one another on being alternately attracted and repelled by electricity; but it appears to me to proceed unquestionably from a sort of crepitation or crackling of electricity escaping through the asperities of the stony surface.

A third observation of the same kind we owe to M. Craveri, who was surprised by the same meteor near the summit of Popocatepetl, September 15, 1855, with this difference, that the incident taking place on fields of snow, the noise of the crepitation of the ground was not produced.

The following are the analogous facts which have come to my knowledge:

In 1767 H. B. de Saussure visited the top of the Brevent in company with Pictet and Jalabert.* The travelers were there directly electrified to such an extent that on stretching out their hands they experienced prickings at the end of the fingers; the electricity escaped from them with a kind of thrilling sensation. Sparks, it was found, might be drawn from the button of a gold band which surrounded one of their hats, and also from the iron end of a mountain staff. These effects were attributed to a great storm-cloud which occupied the middle region of Mont Blanc, and which gradually extended itself above the Brevent. At a dozen toises below the top of that mountain the electricity was no longer perceived. The storm raged around Mont Blanc, but on the Brevent there fell only a light rain of short duration, and then the disturbance was dissipated. From this recital it is easy to see that the storm did not prevail upon the Brevent at the moment of the observation, since there was no rain falling; but that, at this point, the electricity discharged itself in a continuous current by the summit of the mountain.

In 1863, M. Spence Watson, visiting, with some guides the Col de la Jungfrau, was overtaken by a hurricane, attended with hail and snow. The staves commenced their peculiar *chant;* the expeditionists experienced sensations of heat in different parts of their bodies,† especially the head, and the hair stood erect; a guide took off his hat, exclaiming that his head was burning; a veil was kept stiff and straight in the air. Electric currents, at the same time, escaped at the ends of the fingers. Claps of thunder (in the distance, for no lightning was seen) for an instant interrupted the phenomenon. Finally, shocks were felt, and M. Watson had the right arm paralyzed for some minutes. This arm continued for several hours to be the seat of acute pains.‡ During this time *the snow fell whistling like hail.*§ But what is most remarkable was the emission of a noise by the snow, a crackling similar to that of a brisk shower of hail, evidently the analogue of that which the ground of the Nevado de Toluca emitted in the observation above described. The phenomenon lasted 25 minutes. It had no unpleasant consequence, except a burning in the faces of the travelers as if they had been exposed to the sun on the snow.

M. Forbes, while crossing by St. Theodule, heard the chant of the staves, and, in July, 1856, M. Alizier, of Geneva, witnessed the same phenomenon near the summit of the Oldenhorn, when the sky was overcast and a storm was imminent, which burst forth an hour afterwards and *was mingled with hail.*‖ We will not speak of the storm during which Colonel Buchwalder and his aid were struck by lightning on the Sentis, for there the phenomenon was of a different order and falls rather within the category of the thunderbolt.

But the nocturnal illumination of rocks pertains probably to the phenomenon of electric efflux from culminant peaks. M. Fournet cites, on this subject, the striking luminosity of the rocks of the Grands-Mulets (Mont Blanc), observed by M. Blackwall, on the night of August 11, 1854, and which was accompanied

* *Voyage dans les Alpes*, tome ii.

† This sensation of heat seems to me to be of the same kind with the pain which I experienced in the back.

‡ *Alpine Journal*, September, 1863.

§ Probably snow resembling rice, a sleety shower.

‖ See the note of M. C. M. Briquet, (*Echo des Alpes*, 1865, No. 4.) *Sur les phénomenes électriques qui accompagnent les orages à des grandes altitudes*, where these observations are collected and compared. Geneva, 1865.

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by sparks. On the other hand, the phenomenon of electricity displayed on the lakes, and on the very dry plains of elevated plateaux, does not seem to me of the same nature. Finally, the surprising fact of the so-called galloping electricity, coursing over prairies, observed by M. Quiquerez, near Courtamon, may be regarded as a variety of lightning; a miniature lightning, resulting from the fact that the electrified cloud was grazing the earth and discharged itself over the whole surface by a thousand sparks, which were seen to run along the ground. It is probable that these phenomena should be divided into several categories, the causes of which are not identical. Some proceed from a static tension, others from a series of discharges having a certain analogy to lightning.

The phenomenon of the *chant of batons* or staves, in other words, the resonance or *bourdonnement* of the soil, constitutes still another species. It has been observed only on the summit of mountains or of culminant peaks; never, as far as I know, on plains or at the bottom of valleys. It supposes a continuous dynamic action, or an efflux of the fluid towards the clouds by the most salient terrestrial conductors, sensibly different from static tensions and abrupt discharges.

If we collate the observations which have been above indicated, we shall distinguish therein several common features:

1st. The efflux of electricity by the culminant rocks of mountains is produced under a clouded sky, charged with low clouds, enveloping the summits or passing at a small distance above them, but without the occurrence of electric discharges above the place whence the continuous efflux is proceeding. It would seem, therefore, that when this efflux takes place, it sufficiently relieves the electric tension to prevent lightning from being formed.

2d. In all the cases observed, the summit of the mountain was enveloped by a shower of hail or sleet, which leads to the supposition that the continuous efflux of electricity from the ground towards the clouds is not unconnected with the formation of the vapor and probably also with that of the hail.

At the Piz Surley and at the Nevado de Toluca there fell a sleet or snow resembling rice, and at the pass of the Jungfrau the snow fell *whistling like hail*, which seems to indicate that it was rather sleet which was falling than snow.

Doubtless we should take into account the higher temperature of the valleys, where the hail, proceeding to melt, turns into rain; but still we do not think that in the particular cases which we have just indicated the phenomenon of rain falling in the valley and that of the sleet of the isolated mountain peaks relate to a condensation taking place in accordance with identical laws through the whole extent of the sky. Thus, in particular, during the observation of June 22, 1865, I saw on the horizon all the spires of rocks, although isolated and far remote from one another, enveloped by a powdery sleet which continued for a long time, while in the rest of the sky all condensation had ceased, and in the valley there fell a copious shower of rain, but of very short duration.

Moreover, the phenomenon which passed around the summits of the rocks was quite different from that which deluged the valleys. Around these lofty pyramids there were columns of a fine sleet of great rarity; in the valley a heavy and drenching rain, such as the thin sleet of the summits would not have produced had it been converted into water. Around the elevated projections, therefore, by which the electricity was flowing off, the condensation presented the special character of being little abundant, powdery (fine sleet), and more persistent than in the rest of the sky.

The electric phenomenon which has been described, and which we term the electric resonance of the mountains, seems not to be rare in high regions, without, however, being very frequent. Among the guides and hunters whom I have interrogated on the subject, some had never observed it; others had heard it but once or twice in their lives. But it is proper to add that it is precisely on those days when menacing skies repel adventurers from the highest altitudes that the phenomenon manifests itself.

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SYNCHRONOUS SEISMOLOGY.

The year recently closed furnishes interesting corroborative testimony of an apparent law regarding the propagation of earthquake movements *most readily* along great circles of our globe, as well as evidence that these seismic movements are frequently transmitted along belts (approximating to great circles) coincident sometimes with continental trends, at other times with figures which emanate in radii at every 30°, around the pole of the land hemisphere in Switzerland, as described in one of my papers, read at the Montreal meeting of the A. A. A. S.

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SUBTERRANEAN TEMPERATURE.

The driving of the great Simplon tunnel through the Alps is affording some interesting data on the subject of subterranean temperature. The work has progressed in the north heading over 21,000 feet, and in the south heading over 17,000 feet. Temperature observations have been taken both of the rock and the atmosphere. The temperatures of the rock show a steady increase with the depth of penetration in both headings. Thus at 1,640 feet from the portal of the north heading the rock showed a temperature of 54.3 deg. Fah., while in the south heading at the same distance from the portal the temperature was 56.2 degs. At 6,560 feet the temperature in the north heading was 63.6 degs., and in the south heading 69.7 degs. At 12,920 feet from the north heading the temperature was 76,3 degs.; at 15,090 feet it had risen to 86.3 degs., and at 16,400 feet penetration the temperature of the rock was 89.1 degs. The highest temperature recorded previous to September last was 92.2 degs. Fah. Early in October a heavy stream of water was encountered, which temporarily drove the gangs of workmen from the heading and necessitated temporary suspension of work in the main tunnel. The heaviest flow of water recorded at that time was about 200 gallons per second; and while it has been productive of considerable inconvenience in the tunnel work, it brought with it the advantage that it produced a very marked decrease in the temperature of the rock. The temperatures of the air are not given, for the reason that they vary with the amount of ventilation. During the summer it was found necessary to deliver to the northern end of the tunnel 39,000 cubic feet of air, and 66,000 cubic feet to the south end.

Chinese Beliefs about Caves.

MR. HERBERT SPENCER, in his "Principles of Sociology" (3rd edition, New York, vol. i. p. 207), relates the beliefs in the creation of mankind under the ground or in caverns, current among the Todas in Asia, the Basutos in Africa, and at least one-half of the American tribes. A similar belief I have lately found in a Chinese record. In Li Shih's *Sïh Pŏh-wuh-chí* (written in the 13th cent. A.D., Japanese edition, 1683, tom. ii. p. 3) a quotation from the *Ning-kwŏh-lun* runs as follows:—"Primitively there was no Liáu-Kién in Shuh (now Sze Chuen); this tribe emanated from red clay in a cave of Teh-yáng mountain, whence bits of the soil had began to roll out, each roll enlarging them, so that at last thereby was created a couple, who gave birth to many."

In another paragraph Mr. Spencer remarks:—"Stationary descendants of troglodytes think that they return into a subterranean other-world whence they emerged (*ibid.* p. 213). According to this, I would suggest that the same belief, entertained by some aborigines in China, has revived itself among the Taoists, who used to call their paradise the "Cave-Heaven" (Tung-Tièn)—*e.g.* Twan Ching-Shih describes the "Cave-Heaven" 10,000 *lis* in circumference and 2600 *lis* in height (his "Miscellanies," Japanese edition, 1697, tom. ii. p. 1), and Li Shih enumerates thirty-six caves in the empire, all entitled "Heavens" (*ibid.* tom. i, p. 8).

KUMAGUSU MINAKATA.

15 Blithfield Street, Kensington, W., November 2.

The Aurora and the English Telegraphs.

Mr. Culley, Engineer of Telegraphs, writes to the London *Times*:

"As public attention has been directed to the effect of the aurora on the telegraphs, perhaps you will permit one who has been connected with the telegraph from the very first to explain in what manner the transmission of messages is interfered with, and what means are used to keep up the communication.

"The aurora is supposed to be caused by a flow of electricity through the atmosphere at a very great hight, where the air is extremely rare.

"It is, in fact, a kind of lightning, differing from ordinary lightning in being a gentle and gradual flow instead of a violent and sudden discharge.

"The same cause which produces the aurora produces also currents which flow from one part of the earth's surface to another; and, as a telegraphic wire is always connected to the earth at each end, a portion of these currents must necessarily pass through the wire from one station to the other, provided the two stations happen to lie in their course, which is usually, though not always, nearly east and west.

"These so-called 'earth currents' are frequently very powerful (they were specially so, as might have been expected, during the late brilliant displays), but what is more troublesome still, they constantly vary in strength, and also in direction, and, consequently, make it impossible to read a message.

"They also affect the mariners' compass, but not sufficiently to be visible, except under special arrangements. They were powerful enough, however, on Tuesday evening, to deflect the magnet of a Thomson galvanometer, which is really a compass needle very delicately suspended, as much as 200 divisions when it was not connected to any wire whatever.

"It will be obvious, from what has been said, that some telegraph wires are more disturbed than others. Those running nearly east and west suffer most. It will also be readily seen that if the connection with the earth can be dispensed with the currents will not enter the wires.

"When there are several wires available between the two stations the earth connections are cut and the wires are looped, so as to use one of each pair as a return wire in place of the earth, thus forming a complete metallic circuit. But, although this plan is effective, it will be seen that it enables us to use only one half of the instruments affected. At the central office, on Tuesday, we were obliged to loop fifty wires in this manner, losing at once twenty-five circuits.

"We can also connect two wires so as to throw the terminal stations out of the line of disturbance, but, as the direction of the earth current is seldom constant, this method does not give very good results.

"It is also possible in some cases to divide the wire at both ends, introducing a condenser, or very large Leyden jar, and signaling by inductive discharges. This answers perfectly for a cable, but has not at present been found effective for land wires.

SUBTERRANEAN ELECTRICAL DISTURBANCES

A FEW minutes before and after the earthquakes of the 17th March last powerful positive electrical currents were rushing towards England through the two Anglo-American telegraph cables, which are broken near Trinity Bay, Newfoundland. Mr. C. F. Varley, C.E., who informed us of the fact, broaches the novel speculation that some earthquakes may be due to subterranean lightning. He imagines that as the hot centre of the earth is approached, a layer of hot dried rock may be found which is an insulator, while the red hot mass lower down is a conductor. If this conjecture be true—and there is plausibility in it—then the world itself is an enormous Leyden jar, which only requires charging to a very moderate degree to be equal to the production of terrific explosive discharges.

The French Atlantic cable was disturbed at the same time, and so were many of the English land-lines, but the only observations as to the direction of the current were made by means of the Anglo-American telegraph cables.

A number of Mr. Varley's charts about earth-currents were published in the Government Blue Book of 1859-60, showing that the direction of these currents across England was in a very notable degree determined by the contour of the coast, and that the same auror[illegible] would often produce currents at right angles to each other [illegible]

AETHERFORCE

Electric Excitement.

The effect of solar heat, and its daily variation upon the dissimilar material of the earth, as well as a like action of internal fires, are, as we well know, fruitful sources of electric excitement. The vast and energetic actions by which the solar heat and light are maintained, involve among other things, as we have reason to believe, proportionate electric developments in that central source of power, which must in turn, by inductive action, affect our planet. In fact, such an effect may be traced in the most marked manner. Thus, Herschel, in his lecture on the Sun, says, as we shall here quote, simply premising that "sun spots" are believed to be on the sun's surface which could not be estimated at less than thirty-five thousand miles."

"A magnetic storm was in progress at the time. From the 28th of August to the 4th of September, many indications showed the earth to have been in a perfect convulsion of electro-magnetism. When one of the observers I have mentioned had registered his observation, he bethought himself of sending to Kew, where there are self-registering magnetic instruments always at work, recording by photography, at every instant of the twenty-four hours, the positions of three magnetic needles differently arranged. On examining the record of that day, it was found that every moment of time (as if the influence had arrived with the light) all three had made a thoroughly marked jerk from their former positions. By degrees, accounts began to pour in of great Auroras seen on the nights of those days, not only in these latitudes, but at Rome, in the West Indies, on the tropics within 18° of the equator, (where they hardly ever appear;) nay, what is still more striking, in South America and in Australia, where, at Melbourne, on the night of the 2d of September, the greatest Aurora ever seen there, made its appearance. These Auroras were accompanied with unusually great electro-magnetic disturbances in every part of the world. In many places the telegraphic wires struck work. They had too many private messages of their own to convey. At Washington and Philadelphia, in America, the telegraphic signal men received severe electric shocks. At a station in Norway the telegraphic apparatus was set fire to, and at Boston, in North America, a flame of fire followed the pen of Bain's electric telegraph, which, as my hearers perhaps know, writes down the message upon chemically prepared paper."

Such facts as these show a marked connection between disturbances of the sun, which might most naturally be supposed to involve electrical developments in that body, and electric conditions of our earth; and it is, therefore, in no wise unreasonable to suppose that atmospheric electricity may to a great extent, be due, directly or indirectly, to the inductive influence of the sun, aided in its effects by the evaporative actions above described.—*Prof. Henry Morton*

ÆTHERFORCE

Thunderstorm Phenomena on the Matterhorn.

In 1888-1889 I witnessed some eight-and-twenty thunderstorms on the Pampas of South America; and came to the conclusion—

(1) That there was no reason to suppose that the so-called "sheet-lightning," or "summer-lightning," is anything more than the glare of distant spark-discharge;

(2) That by far the greater number of discharges took place between different layers of cloud, and not between clouds and the earth;

(3) That the origin of these storms lay in the electrical excitation due to the friction between opposed currents of air (carrying cloud), upper and lower respectively.

This year I was witness of a thunderstorm under very different circumstances, and I observed a phenomenon that appears to me to be of interest.

On July 10 I was on the Matterhorn in very doubtful weather. It appeared as though the Föhn (or southerly wind) were struggling with a northerly wind, and as though the former conquered. Clouds or mist pressed up from Italy, and rose higher and higher, covering the other mountains before the Matterhorn. We had some snow at intervals even before midday, and by the time that we had, on return from the summit, descended as far as the upper hut, it was snowing steadily. I think that, as regards the Matterhorn, the electrical hissing of ice-axes, rocks, &c., began about 3.30 p.m. or 4 p.m., and lightning began rather later.

At last came one flash, apparently very near to us, the thunder following close with a crash. *Before the thunder*, however, and apparently *with* the flash, came a curious splitting, cracking, and shivering sound, with a kind of "splash" from the rocks—as it seemed. I give many adjectives for want of one good expressive word. This sound preceded the thunder, and was both sharp and faint; I felt that I only heard it because I was on the spot.

Later, another flash came close to us. This time I heard no "splash" from the rocks; but, apparently *with* the flash, and before the thunder-crash, there came a light, shivering, branching crack again, something like the "ghost" of thunder, one might say. It reminded me this time of the shiver that passes over the surface of new snow, only very slightly crusted, when first broken in any part by the feet of a traveller. (Some climbers will know this sound; but I myself have only occasionally noticed it, and that only when I have been the first on a snowfield soon after a heavy fall of snow.) I received a slight shock in the head this time. A third flash gave the same sound as the second; but no others seemed so close, and I never heard this sound again.

It was dark when we reached the lower hut; and all down the arête the brushes of purple light that streamed from our fingers (when held up) and from our axes, hats, hair, &c., were very beautiful. The fingers gave better brushes when wetted. There were numerous brushes streaming from the rocks, these being wet with water melted from the snow.

Some other people who were on the Gorner Grat the same day told me, before I mentioned my experiences, that the lightning seemed to give a splashing sound on the rocks. They also told me that those who wore felt hats, felt return shocks, while those with straw hats did not. All the hats were wet.

So much for observation; now for a theory.

To begin with, since the thunder distinctly crashed *after* the lightning-flash, it would seem that the phenomenon that caused the sound I heard must have preceded the spark.

I would suggest the following explanation.

I do not think that those who have never been actually in a storm realise how very indefinite, in substance and boundaries, "a thundercloud" is. It seems certain that we must not regard it as if it were a polished conductor that is gradually charged until it sparks to earth or to other clouds. More probably there is a fall (or rise) of potential through the substance of the cloud itself. When the stress is too great, there is probably a breakdown along many paths in the form of the fine branching sparks observed when a Wimshurst is used without a condenser. This preliminary breakdown suddenly gives a very much larger potential-difference between the portion of the cloud-masses towards which it takes place; so suddenly in fact, that a spark-discharge occurs before more diffuse modes of readjustment can obtain. It seems to me that it is only by some such preliminary discharge from behind that such irregular "surfaces" as those of clouds could attain the condition requisite for the true spark. In something the same way we can pass a spark between two rough or pointed metal terminals by a sudden discharge through them, while we could not raise them in any slower way to the necessary condition.

According to this view, a slighter and more branching discharge in the body of a cloud would be the necessary preliminary to a regular flash; and the, relatively faint, sound of it would precede the "thunder" of the final flash. When once the flash occurs, resistance is much diminished, and the stress of the whole region is relieved through the path created.

An obvious objection to this view, however, will occur to many. "Would the time-interval be long enough? Would not the first sound be practically heard with the thunder, and be drowned in it?'

Another explanation might be, that (as is often the case with a Wimshurst or other machine) there are fainter, tentative, branching discharges that precede the bright spark. But, if this were the case, they should surely be heard in some cases before any spark occurs at all.

Finally, the sound, though it appeared to come out of the air, might have been due to the movements of the stones and rocks over the surface of the mountain, occurring when the stress was relieved. Such a sound might well reach one before the sound of the spark.

WALTER LARDEN.

R. N. E. College, Devonport, July 24.

ATHERFORCE

THE EARTH AS VIBRANT MAGNET

That the earth may be considered as a great magnet the phenomena of the dip of the needle (544) sufficiently show: and the facts connected with electro-magnetism, as set forth in the preceding pages, lead to the conclusion that, when a magnetic needle is in its natural position of north and south, there exist electrical currents in planes at right angles to the needle descending on its east side, and ascending on its west side; we must hence suppose that currents of Electricity are constantly circulating within the earth, especially near its surface, from east to west, in planes parallel to the magnetic equator.

(715) The cause of these electrical currents has been thus explained.* The earth, during its diurnal motion on its axis from west to east, has its surface successively exposed to the solar rays, in an opposite direction, or from east to west. The surface of the earth, therefore, particularly between the tropics, will be heated and cooled in succession, from east to west, and currents of Electricity on thermo-electric principles will, at the same time, be established in the same direction: now, these currents once established, from east to west, will, of course, give occasion to the magnetism of the earth from north to south. Hence the magnetic directive power of the earth, in a direction nearly parallel with its axis, is derived from the thermo-electric currents induced in its equatorial regions by the unequal distribution of heat there present, and depending principally on its diurnal motion (see pars. 570, 571.) It does not belong to the question to consider whether the phenomena of thermo-electricity actually depend on the decomposition of heat, latent or sensible, as some suppose, the *facts* are well established, and the simple manner in which they account for terrestrial magnetism, gives them a high degree of importance and interest.

(716) The whole subject cannot perhaps be better concluded than with the following quotation, from the work of a highly distinguished philosopher.† "These recent and beautiful discoveries show in the most striking manner, that the operations of nature are more extraordinary, and indicate more of simplicity and wisdom of design in proportion as they are better understood. By what simple expedients, when known, are those wonderful phenomena of the earth's Electricity and Magnetism produced, which formerly appeared so anomalous and perplexing? And what encouragement do these discoveries hold out to us with respect to future discoveries, that may throw still further light upon the operations of the great Architect of the universe?"

* Prout's Bridgewater Treatise, p. 233. † Ibid.

AETHERFORCE

TERRESTRIAL MAGNETISM.*

To the Editor of the Scientific American:

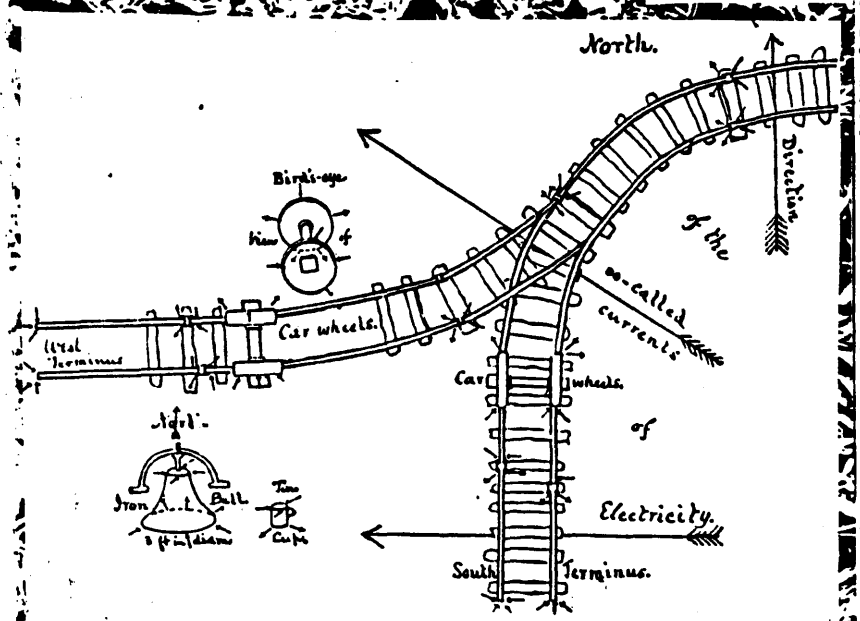
An item has appeared recently in several papers, stating that New York is a highly magnetized city—that the elevated railroad, Brooklyn Bridge cables, etc., are all highly magnetized. As this might convey to the general reader the impression that the magnetism thus exhibited was peculiar to New York city, and as many of your subscribers look anxiously for your answers to numerous questions put for the elucidation of apparent, scientific mysteries, I have thought that perhaps a statement in plain language of experiments made at various times, to elucidate this subject, might, in conjunction with a diagram, serve to explain even to those who have not made a special study of science a few of the interesting phenomena connected with

TERRESTRIAL MAGNETISM.

[illegible] dated Jan. 20, 1877, I [illegible]

"Every article of iron or steel or tinned iron, by the earth's induction, becomes magnetic. Thus, if we examine our stoves, or a doorlock, or long vertical hinge, or even a high tin cup, by holding a delicate magnetic needle in the hand near those objects, we find the earth has, by induction, attracted to the lower end of the stove utensils, etc., the opposite magnetism from its own; and repelled to the upper end of the stove, etc., the same magnetism which exists in our northern hemisphere. Consequently, the bottom of the stove, or of the hinge, cup, etc., will attract the south (or unmarked end) of our needle; while the top of the stove, etc., attracts the north, or marked end, of our magnetic needle. If we apply our needle to the T rails of a N. and S. railroad, we not only find that the lower flange of the rail attracts the S. end of our needle, while the upper flange attracts the N. end of our needle, but we also find, where the two rails come nearly together (say within two inches), that the N. end of the rail attracts the S. end of our needle, while the S. end of the rail attracts the N. (or marked) end of our magnetic needle."

Quite recently, being anxious to see the effect produced on the needle by rails laid E. and W., I experimented on some recently laid here; starting from a S. terminus, in the town of New Harmony, and gradually curving northeast, until the road pursues a due east course to Evansville. There is, however, a branch road of about half a mile, which starts from the Wabash River, at a west terminus, and runs due east to join the other, near where that main track commences its northeast curve. The results (more readily understood by an inspection of the diagram) were as follows:



MAGNETISM ON RAILWAYS.

1. The flange of the north end of any rail would attract the unmarked, while the south end of its neighbor or any other of the north and south laid rails would attract the marked end.

2. The same results were obtained from rails laid all around the northeast curve, and even after they had acquired a due west to east course; showing that each rail acquired the same magnetic polarity which would be exhibited by any magnetic needle oscillating freely in our northern hemisphere, dipping also at its north end considerably downward if suspended at its center of gravity.

3. Applying the needle at the *west* terminus, a few anomalies were observed; but, especially nearer the junction, the rails all gave the normal result found on the main track.

4. The wheels of the cars standing on the north and south track followed the same law, exhibiting both vertical and lateral induction, so that the lower rims and the forward or north part of the periphery attracted the unmarked end of the needle, while the upper and rear, or south portions of the periphery of the wheel attracted the marked end.

5. The wheels of cars standing on the east and west road exhibited the following modification. The lowest rim of all the wheels, whether standing on the *north* rails or on the *south* rails of said track, in consequence of vertical induction attracted the unmarked end of the needle, and the upper rims attracted the marked end of the needle; but the middle portions of the periphery, both anterior and posterior, of the wheels standing on the north rail, attracted the unmarked end, while similar middle portions of wheels standing on south rails attracted the marked end; in consequence of horizontal induction, the wheels being connected by iron axles, and thus presenting considerable extension *across* the track, viz., from south to north.

Magnetite seems to have acquired its polarity in the same manner, namely by the earth's induction, when the ore contains a large enough percentage of pure iron. A large specimen (6 in. long by 8½ deep and weighing 5½ lb.) which I obtained from near Pilot Knob, Missouri, exhibits polarity, not only at its lateral ends, but also vertically, as the lower surface attracts the unmarked end of a needle, while the plane, which evidently occupied the upper surface in its native bed, attracts the marked end of the needle.

Iron fences invariably exhibit only the polarity by vertical induction; so also small buckets, bells, etc. But in the case of a bell about 3 ft. in diameter at its base, and over two feet deep, tapering to about a foot in diameter at the top, I found that although the top attracted the marked end of the needle, the bottom attracted the unmarked end of the needle only around the northerly half of the circumference, while the southern portion of this lower rim attracted the marked end in consequence of lateral induction, as in N. and S. rails.

Thus, upon a comparison of all these facts, it would appear that, if the magnetism induced by the earth is due to so-called currents of electricity, those currents must be *underneath* the rails, and must move from west to east, under the south to north rails, and from south to north under the west to east laid rails, as indicated by the arrows in the diagram.

This accords perfectly with what we should theoretically expect, in our northern hemisphere, if the electricity in the earth's crust is due to thermo electrical currents from east to west, namely, from the more heated to the less heated portion, on any given latitude, while the earth revolves from west to east; as well as also from electrical currents trending from tropical to Arctic regions.

As the network of iron rails spreads from year to year more extensively over our continent, it will be interesting to observe whether or not any effect is produced, perceptible [illegible] cal, agricultural, etc., by this diffusion of [illegible]

AETHERFORCE

The consideration of the *power* of the great earth-magnet must be for a moment laid on one side, while we deal with a form of deviation as remarkable as the declination. We refer to the *dip* of the needle. The ordinary compass is, we know, suspended horizontally, and, for anything which appears to the contrary when we examine such an instrument, that might be the needle's position of rest. But when a needle is so suspended by a silken thread as to be free to assume an inclined position, it is found that the northern end dips perceptibly. We are assuming, of course, that in its non-magnetized state the needle would rest horizontally. In our latitudes, the dip or inclination is so great that the needle is inclined only about 22 degrees to the vertical. When we travel northwards, the dip increases; when southwards, it diminishes, until we reach a place near the equator (traveling always, it is assumed, in the longitude of London) where the needle becomes horizontal. After passing that point, the southern end dips, and the inclination continues to increase as we travel southwards.

The same is true for other longitudes, only the place of "no dip" is differently situated. The line along which there is no inclination lies near the equator, crossing that circle at two opposite points, one in west longitude 3 degrees, the other in east longitude 177 degrees. The magnetic equator is not a strictly circular curve, however; it is noteworthy that it departs most from the figure of a true circle where it traverses the Atlantic Ocean.

We have seen the variations which are exhibited in the declination of the magnet, not only at different places, but at different times in the same place. Changes of precisely the same character are exhibited in the dip of the magnet; in London, for example, the dip has diminished four degrees in less than a century; in Paris, during the last two centuries, the dip has diminished about seven degrees.

Seeing this, we must accept with some little question the locales usually assigned to the magnetic poles; because we have every reason for supposing that these poles must be continually shifting their position. In fact, the motion of the magnetic equator, which is continually sweeping from east to west along the true equator, suffices of itself to demonstrate that the magnetic poles are continually traveling around the true poles. What the laws of this motion may be, it would not be easy to determine in the present state of our knowledge; but it is worthy of notice that the same motion would serve to account at once for the change of dip and the change of declination. For example, in 1663 the magnetic pole may be reasonably supposed to have been due north of Paris. In the latter year, the inclination was 73 degrees in Paris, so that we can judge that the magnetic pole was on the nearer side of the true pole. As the magnetic pole passed away from this position, traveling westward, there would naturally result both a westerly declination and a gradual diminution of dip. And the fact that when Sir J. C. Ross determined the position of the northern pole in 1837, it was found to be somewhat more than 90 degrees west of the longitude of Paris—in other words, the fact that it had traversed somewhat more than a quarter of a complete revolution soon after the westerly declination at Paris had attained its maximum value—seems strikingly confirmatory of this view. If this theory is correct, the inclination will continue to diminish until the magnetic pole has completed half a revolution, so as to be again due north of Paris, but on the further side of the true pole. Then the declination will be nothing, and it will afterwards become easterly.

It must be admitted, however, that there is much more complexity in the laws according to which the declination varies, than the above view, taken alone would imply. Doubtless, the peculiarities of the earth's structure, the arrangement of land and water, mountain-ranges, table-lands, and valleys, have much to do with the matter.

The variations of the intensity of magnetic action, either from time to time, or as we proceed from place to place, are among the most interesting of all the phenomena of terrestrial magnetism. The latter class of change is associated so obviously with the changes of declination and dip, that we need not enter on its consideration. The former, however, points to problems of extreme interest in connection with the probable character and source of the whole range of forces included under the subject we are dealing with.

We have seen already that from hour to hour, and from day to day, there are changes in the extent of the minute oscillations of the suspended magnet, and that these changes indicate variations in the intensity of the magnetic forces under diurnal and annual solar influences. When we add to these variations a change which has a period corresponding to the motions of the moon, it becomes evident that it is to an influence as subtile and as pervading in its character as gravitation itself, that the terrestrial magnet owes its powers.

But there are other variations still more significant.

A long series of researches had convinced Colonel Sabine, one of our leading authorities on the subject of terrestrial magnetism, that the intensity of the magnetic action is subject to a process of change having a period of somewhat more than ten years.

ÆTHERFORCE

At no great distance from Constantinople is the ancient town of Magnesia, once a city, and the residence of the great Ottaman rulers of the East, and the centre of Oriental splendor. A pleasant ride from this old Magnesia brings us to the vicinity of the most remarkable iron-mines in the world; remarkable not for the quantity of metal produced, but for the peculiar properties of the ore. The mineral here obtained has the specific name of loadstone, or (as now corrupted) lodestone. If a strip of this stone be balanced on a point, it will turn on that point till it takes a direction which is opposite to the motion of the earth; and as the globe revolves from west to east, so therefore does the loadstone stand in a direction north and south.

According both to history and tradition, round and about Magnesia dwelt, at a very remote period, a civilised race. Men of thought and science naturally had their attention directed to the astonishing and almost life-like property of this stone. Nearly all of us have read, or intend to read, the story of Sinbad the Sailor, in the "Arabian Nights' Entertainments." How long ago it is since that tale was written it is difficult to say; but it is certain that it was as popular before the Christian era as it is now. The loadstone of the tale is the Mountain of Adamant, which drew the nails out of the wonderful navigator's ship. We read in the legend, "that about noon we had come so near that we found what the pilot had foretold to be true, for we saw all the nails and iron in the ship fly towards the mountain by the violence of attraction, with a horrible noise; so the ship split and sank into the sea."

Since the Crimean war navigation has been much extended in the Black Sea, and here is a confirmation of the Arabian fable by a recent traveler. "Ships have, lately run ashore on the coasts of the Black Sea near Sinope; and the captain of one that narrowly escaped wreck, suspected that the compass had been deflected by magnetic influence. This suspicion led to an investigation, which has issued in the discovery of a valuable mine of iron ore or loadstone on those coasts, the danger of which is calamitous." Now if this, or the mines near Magnesia, (and both are not far apart,) be not the identical Mountain of Adamant referred to by Sinbad, it is certainly a very remarkable coincidence.

The power which we call magnetism, derives its name from Magnesia, because of this loadstone; and as the subject is an old one, we ought perhaps to know all about it; but nevertheless, it still mystifies the most profound philosophers. What we do know has been discovered by men of our own age.

As we have before said, if a piece of this adamant, or loadstone, be balanced, it will turn till its direction is north and south, and then remain stationary; but this is not all, for the loadstone has the power to impart the same quality to a piece of steel, which it does by mere friction, losing by the operation not the slightest power itself, yet giving to the steel no less an amount of power than itself possesses; and steel thus treated is said to be magnetised. But this power of placing itself at right angles to the motion of the earth is not the only quality that a magnet possesses. The attractive influence it exercises over iron and steel is no less wonderful, and indeed so much so that considerable force is necessary to remove the object attracted, when once brought in contact with it. A number of mechanicians are now engaged in solving the problem—how to make this power useful for locomotion, and there is great probability that they may eventually succeed. Although we are not able to explain the cause of magnetism, yet we have ascertained that it is intimately connected with electricity, for we can produce the one from the other. The mariner's compass consists of a piece of steel shaped like an arrow, that has been rubbed with either a loadstone or magnet. When thus treated, it is called a magnetic needle; it is the points of the horizon; in this way it becomes useful to the traveller by land and by sea, as he can direct his course to any point he pleases, knowing well that—

> The obedient steel with living instinct moves,
> And veers for ever to the pole it loves.

Hence the old name lead-stone is correct.

Another remarkable property inherent in magnet is that of having a power, which we call the repulsive or repelling power, this is no less active than its attracting power. In this way the chemists have given to the mechanics two horses,—one that pushes and one that pulls; and it is for them to solve the means of harnessing them to a vehicle—a feat probably beyond the horse-taming powers of Mr. Rarey himself. SEPTIMUS PIESSE.

ÆTHERFORCE

The easterly declination of the needle in London was observed to disappear in about the year 1657. From that epoch, the needle continually traveled westwards, until it began to be thought that it would move ever in that direction, and so come at length to point southwards. In Paris, the easterly declination had not disappeared before the year 1663, and there also the needle traveled continually westwards, though not quite so rapidly as in London. In 1814, the needle pointed about 22½ degrees towards the west in Paris, and some two degrees further west in London. In that year, however, Arago startled the scientific world by announcing that in his opinion the needle's westerly motion was flagging, and he asserted his belief that that motion would presently give place to an easterly movement. Only three years passed before the prediction was fulfilled; and on the 19th of April, 1817, Arago was able to announce that the needle had begun to return towards the north. But observers in London pronounced against this view. The London needles were still traveling westward, though with a slowly diminishing motion. It was not until the spring of 1819 that the London observers admitted that the needles had really reached the limit of their westerly oscillation. And whereas in Paris the needles had not traveled more than 22½ degrees towards the west, in London they had passed no less than 25 degrees from the north point. Corresponding to this circumstance, we see also that the duration of the half-oscillation (for the needles had not been watched from their greatest easterly declinations) was a hundred and sixty-two years in London, and a hundred and fifty-four years in Paris.

It gives a grand idea of the nature of those ever-acting forces to which terrestrial magnetism is due, to consider that the sway of the magnetic needle from limit to limit of its range should occupy so long an interval as three centuries in both these instances. Conceive the scale on which a pendulum should be constructed in order that its oscillations might have a period of as many seconds!

It was while they were engaged in tracking the progress of this long oscillation, that physicists detected minute oscillations superposed, so to speak, upon the main one, and even more singular in their character. The case is somewhat as though to the bob of a long pendulum there were attached a short one, and that it was to the motions of this short pendulum (beating with its own rapid swing, while carried slowly backward and forward by the main movement) that attention was primarily directed.

Each day the magnetic needle sways backward and forward *twice* across its mean position. Shortly before midnight, it begins to travel from west to east, reaching the limit of that motion soon after eight in the morning. Then it sweeps westward to its greatest westerly limit, which it reaches soon after one. Then back again towards the east, until half-past eight, and so to its original position at about eleven o'clock.

It must be understood that these motions are so minute in comparison with the great secular oscillation, that they never affect the general direction of the magnet to any noteworthy extent. For instance, we have just spoken of the two easterly limits of the daily swing, but throughout the day the magnet always points far to the west of north. The mean declination, in fact, is (roughly) about 20 degrees, whereas the daily swing never ranges over more than the fifth part of a degree.

It will be noticed that the oscillations above described correspond closely with the diurnal motions of the sun. They are such, in fact, as the needle would exhibit on the supposition that it tries to follow the sun during his complete apparent revolution round the celestial sphere. It is believed that the daily motions of flowers, and in particular that class of motion which has given the sun-flower its distinctive appellation, are due to the same magnetic properties which cause the diurnal swing of the suspended needle.

But besides the daily sway of the magnetic needle, there is an annual oscillation of a somewhat different character. In fact, properly speaking, the annual change is not oscillatory, though it has a regularly recurrent character. The daily swing is variable. Now this variability would be somewhat confusing, on account of its general irregularity; therefore, physicists consider the mean of several days, and thus get rid of what for the present we may term accidental variations. When this has been done, it is found that the average daily swing of the needle is subject to a slow progressive increase, followed by an equally slow diminution; and the period of these slow changes is a year.

The peculiarity of this annual change is that its progress is the same for both hemispheres.

AETHERFORCE

MAGNETISM IN CITIES.†

It has long been known that iron when subjected to repeated blows and shocks, while under the influence of a magnet, attains permanent magnetic qualities. Soft iron of pure quality is affected very little in this way, whereas impure wrought and cast-iron are capable of being permanently magnetised to a considerable extent.

As early as the year 1600, Gilbert experimented in this direction by placing bars of iron in the magnetic meridian and striking them with a hammer. It would require very little imagination, therefore, to suppose that, in a busy city containing iron structures of all kinds, the latter should possess magnetic qualities, since they are constantly subjected to shocks and vibrations produced by traffic.

Such, indeed, is the case, and we propose to give here the results of a few experiments, made with the view of determining their character and extent. The results demonstrate anew the powerful magnetic inductive action of the earth, and show some curious facts. It may be well to remark that in what follows polarity is always designated with respect to the needle, the end pointing toward the north being called the *north pole*; accordingly, therefore, the polarity of the northern hemisphere will be *south*.

The instrument used in these trials consisted of a surveyor's compass; the needle being about four inches long and delicately mounted, so that even very slight indications of magnetism were observed by it.

The first object investigated was the structure of the elevated railroads in New York city. For those not acquainted with them it might be well to explain that they consist essentially of wrought iron posts, or columns, which support trusses or open beams, upon which the tracks are laid.

Beginning with the posts, an examination of a large number of them showed that with very few exceptions they possessed magnetism, and that their *lower* extremities were *north* poles, without a single exception. The examination extended in various directions in the city, and posts distant seven miles from one an other showed the same polarity. It was also observed, that while some gave very strong indications, others gave very little, but not one showed south polarity at the ground. So also did the cast-iron foundation blocks show decided north polarity.

An examination of the superstructure showed that all vertical posts were more or less permanently magnetised, their *lower* extremities being *north* poles. Thus the cast-iron columns which support the roofs of the stations showed this property to a remarkable degree, as did likewise a stove in the waiting room at the station. A screen of half-inch iron rods showed the same property; here also the end of a gas pipe showed south polarity.

As regards the trusses which stretch from post to post, it was found that they were magnetised in such a manner, that their *lower* chords were *north* and their upper south poles. They constitute, therefore, long magnets with poles in the direction of their breadth instead of their length, as is generally the case.

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At a meeting of the Seismological Society of Tokio held on November 18, 1885, in the University there, Prof. Shida described an instrument which he had designed to give an automatic record of earth-currents. The chief feature in it is an ingenious method of obtaining a record of the position of the coil or needle which indicated the current which might be passing through the instrument. This was accomplished by the needle, as it turned, making a series of almost frictionless electrical contacts between a series of metallic points and a film of [illegible]. The instrument has been practically worked, and is said to have yielded satisfactory records. A second paper by the same writer gave a history of all the facts with which we are acquainted respecting the phenomena of earth-currents. A considerable portion of the material embodied in the paper was derived from Prof. Shida's own observations on the lines and cables of this country. He made numerous references to instances where earth-currents of unusual magnitude had accompanied or preceded earthquakes. Many theories have been advanced to account for these phenomena, and it has been demonstrated by several investigations that they have a connection with the occurrence of sunspots. In the discussion which followed, Prof. Knott referred to the possibility of these disturbances being due to the inductive action of electrified bodies of air, while Prof. Milne added to the instances adduced by Prof. Shida of the simultaneous occurrence of earthquakes and earth-currents. Earthquakes occurring in America have, by the currents which had accompanied them, recorded themselves in Europe.

—Observations of Olbers' comet (1815 I.) on its return in 1887, made at the Observatory of Bordeaux with the 0·38 m. equatorial by MM. G. Rayet and Courty. The observations cover the time from September 8–10 inclusive, and comprise the mean position of three stars taken as points of comparison.—Observations of Brooks's new comet (August 24, 1887) made at the Observatory of Nice with the 0·38 m. Gautier equatorial, by M. Charlois. The apparent positions are given for the period from August 25 to September 2 inclusive. On the former date the comet had a nucleus of the tenth magnitude surrounded by an elongated nebulosity at the angle of position of 304°.—On the variations of the telluric currents, by M. J. J. Landerer. During the last nine years, the number of days when the current flowed north-east and south-west being indicated by 1, those on which it flowed in the opposite direction will be represented by 6·7. Several changes of direction very seldom occurred on the same day, and they were nearly always connected with violent atmospheric disturbances. From 8 a.m. to 9 p.m. the intensity of the current going north-eastwards attained a maximum towards 10 o'clock and two minima about 4 and 9 o'clock, the mean intensity of the maximum being 0·000124 ampere, that of the minima 0·000073 and 0·000074. For the opposite current this maximum and these minima become respectively one minimum and two maxima at about the same hours, with mean intensities 0·00064, 0·000122 and 0·000138 ampere.

MANCHESTER

Literary and Philosophical Society, February 6.—E. W. Binney, F.R.S., president, in the chair. Dr. Joule, F.R.S., called attention to the very extraordinary magnetic disturbances on the afternoon of the 4th instant, and from which he anticipated the aurora which afterwards took place. The horizontally suspended needle was pretty steady in the forenoon of that day, but about 4 P.M. the north end was deflected strongly to the east of the magnetic meridian, and afterwards still more strongly to the west. The following were the observations made :—

Time	Deflection from the Magnetic Meridian.	Time	Deflection from the Magnetic Meridian.
4.0 P.M.	0 50 E.	6.10 P.M.	1 24 W.
4.30 ,,	0 47 W.	6.12 ,,	1 8 ,,
4.55 ,,	2 22 ,,	7.41 ,,	0 10 ,,
4.58 ,,	3 0 ,,	7.43 ,,	0 0 ,,
5.9 ,,	3 45 ,,	8.9 ,,	0 42 ,,
5.12 ,,	0 52 ,,	8.31 ,,	0 10 ,,
5.23 ,,	5 36 ,,	8.54 ,,	1 18 ,,
5.24 ,,	2 28 ,,	8.58 ,,	0 52 ,,
5.35 ,,	0 52 ,,	11.3 ,,	0 5 ,,
5.55 ,,	0 52 ,,		

Mr. Sidebotham states that he also expected the magnificent aurora on account of the violent disturbance of the needle at Bowdon, amounting to at least 3°. Observation with the spectroscope by Dr. Joule showed a bright and almost colourless line near the yellow part of the spectrum. This line appeared in whatever part of the heavens the instrument was directed, and could be plainly seen when the sky was covered with clouds and rain was falling. When looking at the most brilliant red light of the aurora a faint red light was seen at the red end of the spectrum, and beyond the bright white line, towards the violet end, two broad bands of faint white light. Mr. Thomas Harrison stated that he saw the aurora on last Sunday evening from $6^h\ 15^m$ to $9^h\ 30^m$ and took spectroscopic observations thereon from various parts of the sky. In each case, however, he discovered only one bright yellow line, situated between D and E, being on Kirchhoff's scale about 1255 to 1260. He is not acquainted with any known substance that gives a corresponding line. The line throughout was very clear and decided, both in the narrow and wide slit; but he failed to discover any continuous spectrum. The line was also very perceptible by reflection from those parts of the sky in which no trace of aurora was visible; and although the streaks were both red and white, the spectroscope appeared to give the aurora as a monochromatic light.

ATHENÆUM

MODELLING VRILLIC ACCUMULATORS AND CORRESPONDERS

"In order to render the experiment more strongly representative of the actual state of the earth, the globe in the state above described, was covered by the gores of a common globe, which were laid on so as to bring the poles of this wire arrangement into the situation of the earth's magnetic poles, according to the best observations we have for this determination; I therefore placed them in latitude 72° north, and 72° south, and on the meridian corresponding with 76° west, by which means the magnetic and true equators cut one another at about 14° east and 166° west longitude.

"The globe being thus completed, a delicate needle must be suspended above it, neutralized from the effect of the earth's magnetism, according to the principle I employed in my observations on the daily variation, and described in the Philosophical Transactions for 1823; by which means it will become entirely under the superficial galvanic arrangement just described. Conceive the globe now to be placed so as to bring London into the zenith, then the two ends of the conducting wire being connected with the poles of a powerful battery, it will be seen immediately that the needle, which was before indifferent to any direction, will have its north end depressed about 70°, as nearly as the eye can judge, *which is the actual dip in London.* If now we turn the globe about on its support, so as to bring to the zenith places equally distant with England from the magnetic pole, we shall find the dip remains the same; but the variation will continually change, being first zero, and then gradually increasing eastward as happens on the earth. If again we turn the globe so as to make the pole approach the zenith, the dip will increase, till at the pole itself the needle will become perfectly vertical. Making now this pole recede, the dip will decrease till at the equator it vanishes, the needle becoming horizontal; continuing the motion, and approaching the south pole, the south end of the needle will be found to dip, increasing continually from the equator to the pole, where it becomes again vertical, but reversed as regards its verticality at the north pole."

(571) But although a sphere thus arranged may be made to exhibit the phenomena of terrestrial magnetism without the aid of any magnetic body, we have yet to learn how such a system of electrical currents can have existence in the earth, unless we refer them to the action of the sun on a metallic thermo-electric apparatus distributed over the earth. It would still, however, remain to be shown what this thermo-electric apparatus is, and where and how it is distributed.

Whether we seek for a cause of terrestrial magnetism in electrical currents, induced on the earth's surface, or whether we refer it to magnetism induced on the ferruginous matter it contains, or in its atmosphere, we are limited to the *Sun*, if not as a primary cause, at least as

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an agent, to which magnetic phenomena have a distinct reference; future investigation must decide whether it acts by its heat, or by its light, or by specific rays or influences of a magnetic nature. Barlocci and Zantedeschi found that both natural and artificial magnets had their magnetism greatly increased by exposure to common solar rays; a result which could not arise from their *heating* power, as an increase of temperature invariably diminishes the power of magnets.

(572) It is an admitted fact that the *aurora borealis* is a powerful source of magnetism, and that the *south* pole of the needle has a distinct connexion with it. Dr. Dalton, in a work published in 1793, has advanced several ingenious hypothetical views, respecting the cause of the aurora, and its magnetic influence. He says, "the region of the aurora is one hundred and fifty miles above the earth's surface. Immediately above the earth's surface is the region of the clouds, then the region of the meteors, called falling stars and fire-balls, and beyond this region is that of the aurora."*

"We are under the necessity of considering the *beams* of the *aurora borealis* of a *ferruginous* nature, because nothing else is known to be magnetic; and consequently that there exists in the higher region of the atmosphere, an electric fluid partaking of the properties of *iron*, or rather of *magnetic steel;* and that this fluid, doubtless from its magnetic property, assumes the form of cylindrical beams.

"With regard to the exciting cause of the aurora, I believe it will be found in change of temperature. Nothing is known to affect the magnetism of steel: heat weakens and destroys it; electricity does more; it sometimes changes the pole of one denomination to that of another, or inverts the magnetism. Hence we are obliged to have recourse to one of these two agents, in accounting for the mutations above mentioned. As for heat, we should find it difficult, I believe, to assign a reason for such sudden and irregular productions of it in the higher regions of the atmosphere, without introducing electricity as an agent in these productions; but rather than make such a supposition, it would be more philosophical to suppose electricity to produce the effect on magnetic matter IMMEDIATELY. The beams of the *aurora* being magnetic will have their magnetism weakened, destroyed, or inverted, *pro tempore*, by the several shocks they receive during the aurora." In another place he says, "I conceive that a beam may have its magnetism inverted, and exist so for a time, &c." Again, "As the beams are swimming in a fluid of equal density with themselves, they are in

* Dr. Dalton adduces in proof of the great height of the aurora its extremely attenuated light, which, he says, may spread over one-half of the hemisphere, and not yield more light than the full moon: this, he says, arises from the extreme rarefaction of the air.

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the same predicament as a magnetic bar or needle swimming in a fluid of the same specific gravity with itself: but this last will only rest in *equilibrio*, when in the direction of the *dipping needle*, owing to what is called the *earth's magnetism;* and as the former also rests in that position only, the effects being similar, we must, by the rules of philosophising, ascribe them to the same cause. Hence then it follows, THAT THE AURORA BOREALIS IS A MAGNETIC PHENOMENON, AND ITS BEAMS ARE GOVERNED BY THE EARTH'S MAGNETISM. I am aware that an objection may be stated to this; if the beams be swimming in a fluid of equal density, it will be said they ought to be drawn down by the action of the earth's magnetism. Upon this I may observe, that it is not my business to show why this is not the case, because I propose the magnetism of the beams as a thing demonstrable, and not as a hypothesis. We are not to deny the cause of gravity, because we cannot show how the effect is produced. May not the difficulty be removed by supposing the beams of *less* density than the surrounding fluid?"

Lastly, although it has been clearly proved that a source of magnetism does exist in the atmosphere, yet it may be asked if there is any reason for believing that the magnetism in the atmosphere is strong enough to be considered as the *only* source of terrestrial magnetism. It has been shown by M. Arago, that the auroræ which exist only at St. Petersburg, in Siberia, and even in North America, actually disturb the magnetic needle at Paris; and he considers it highly probable that the auroræ even round the south pole of our globe extend their influence to Paris. Sufficient, however, has, I think, been said, to show that many more enquiries are wanting, before the question as to the true cause or causes of terrestrial magnetism can be satisfactorily answered.*

* See two papers entitled "Contributions to Terrestrial Magnetism," communicated to the Royal Society by Major Sabine, and read March 19th, 1840, and Feb. 11th, 1841. See also a full account of a very extensive series of observations made at the magnetic observatories of Toronto, Trevandrum, St. Helena, and the Cape of Good Hope, during a remarkable magnetic disturbance on the 25th and 26th of September, 1841, in the 20th vol. of the L. and E. Phil. Mag. Also a notice of a remarkable magnetic disturbance which occurred on the 2nd and 4th of July 1842, observed at the Dublin Magnetical Observatory, and communicated to the Phil. Mag. Vol. xxi. by Dr. Lloyd.

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VRIL AND ITS SEVERAL BY-PRODUCTS IN THE PRESENCE OF INERTIA

(562) In April 1836, Baron Alexander Von Humboldt addressed a letter to His Royal Highness the Duke of Sussex, president of the Royal Society of London, to solicit the co-operation of that body towards the advancement of the knowledge of terrestrial magnetism, by the establishment of magnetic stations, and corresponding observations, and soliciting it to extend, in the colonies of Great Britain, the line of simultaneous observations; these stations he proposed to be established, either in the tropical regions on each side of the magnetic equator, or in the high latitudes of the southern hemisphere, and Canada.

This distinguished traveller has been for many years much occupied with the phenomena of the intensity of the magnetic forces, and the inclination and declination of the magnetic needle. During the years 1806 and 1807, particularly at the periods of the equinoxes and solstices, he measured the angular alterations of the magnetic meridian, at intervals of an hour, often of half an hour, without interruption, during four, five, and six days, and as many nights, in a large garden at Berlin. The instrument he employed was a magnetic telescope *(lunette aimantée)* of Prony, capable of being reversed upon its axis, suspended according to the method of Coulomb, placed in a glass frame, and directed towards a very distant meridian mark, the divisions of which, illuminated during the night, indicated even six or seven seconds of *horary* variation. In verifying the habitual regularity of a *nocturnal period*, he was struck with the frequency of the perturbations, especially of oscillations, the amplitude of which extended beyond all the divisions of the scale, and which occurred repeatedly at the same hours before sun-rise, and the violent and accelerated movements of which could not be attributed to any accidental mechanical cause. These vagaries of the needle, the almost periodical return of which has been recently confirmed by M. Kupffer, appeared to Humboldt the effect of a re-action of the interior of the earth towards the surface, of *magnetic storms*, which indicate a rapid change of tension. From that time, he says, he has been anxious to establish on the east and west of the meridian of Berlin, apparatus similar to his own, in order to obtain corresponding observations, made at great distances, and at the same hours.

(563) In 1827, Baron Humboldt renewed these observations at Berlin, and endeavoured at the same time to generalize the means of simultaneous observations, the accidental employment of which had

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produced such important results. One of Gambey's compasses was placed in the *magnetic pavilion*, in which no portion of iron was introduced, which had been erected in the middle of a garden. At his request, the Imperial Academy and the Curator of the University of Cazan, erected *magnetic houses* at St. Petersburgh and at Cazan, and the Imperial Department for Mines having concurred in the same object, *magnetic stations* have been successively established at Moscow, Barnaoul, and at Nertschinsk. The Academy of St. Petersburgh has done still more, and has sent a courageous and clever astronomer, M. George Fuss, the brother of its perpetual secretary, to Pekin, and has procured the erection there of a *magnetic pavilion* in the convent garden of the Monks of the Greek church. Since the return of M. Fuss, M. Kowanko continues the observations of horary declination, corresponding to those of Germany, St. Petersburgh, Cazan, and Nicolajeff in the Crimea, where Admiral Greigh has established one of Gambey's compasses, the care of which is confided to the director of the observatory, Mr. Knorre. A magnetic apparatus has also been established at the depth of thirty-five fathoms, in an adit in the mines of Freiberg, in Saxony, where M. Reich, to whom we are indebted for valuable experiments and observations upon the mean temperature of the earth at different depths, is assiduously engaged in making observations at regulated intervals. Observations of horary declination, made at Marmato, in the province of Antioquia, in South America, in north lat. 5°27′, in a place where, as at Cazan and Barnaoul, in Asia, the declination is eastern, have been transmitted by M. Boussingault; while on the north-western coasts of the new continent, at Sitka, in the Russian settlements, Baron Von Wrangal, also provided with one of Gambey's compasses, has taken part in the simultaneous observations made at the time of the solstices and equinoxes. Magnetic apparatus have also been sent by Baron Humboldt to Havannah and Cuba; and M. Arago has erected a compass, at his own expence, in the interior of Mexico, where the soil is elevated six thousand feet above the level of the sea. Preparations are likewise making for the establishment of a magnetic station in Iceland.

(564) The suggestions of Baron Humboldt received from the Royal Society the attention which they merited; and a committee was appointed for carrying his recommendations into effect. Conformably with the report made by this committee, the ten following places were fixed on by the council, as being the most eligible for carrying on magnetic observations, according to the plan recommended by Baron Von Humboldt:—Gibraltar, Corfu, Ceylon, Hobart Town, Jamaica, Barbadoes, Newfoundland, Toronto, Bagdad, and the Cape of Good Hope; these places being permanent stations.

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1221. *Electric Earth-Current Disturbances and their Origin.* **J. E. Taylor.** (Roy. Soc., Proc. 71. pp. 225–227, Feb. 18, 1903.)—The author refers to disturbances noticed during experiments on wireless telegraphy for the British Postal Telegraphs. The noises are distinct from the ordinary telegraphic and inductive disturbances. They are more frequent in summer than in winter, most in evidence for a few hours about sunset, and herald the approach of a storm or gale. The noises recall flowing and bubbling water, further, crackling and rocket discharges; these latter the author ascribes to the passage of meteors which set up electric discharges in the upper rarefied atmosphere. The other noises he connects with the ionisation of the air; disturbances are caused when the ionisation is dissipated by an electric field. There are also high-frequency effects noticeable only on the coherers or other forms of Hertzian-wave receivers. H. B.

1222. *Dispersion of Atmospheric Electricity.* **P. Czermak.** (Phys. Zeitschr. 4. p. 271, Feb. 1, 1903.)—From one year's observations, the author concludes that the dispersion has its minimum in winter and a steady high value in summer. The dispersion begins to decrease in autumn and sinks to its minimum with snowfall, probably because frost and snow prevent the ionisation through emanations from the soil (Elster and Geitel). The daily minimum lies between 11 a.m. and noon; the maximum between 4 and 8 p.m.; at higher elevations the extremes are delayed by two hours. High dispersions are observed with foehn winds (in winter) and with cumulus formation. H. B.

1573. *Electrodynamical Investigation of the Earth's Crust.* **E. Lecher** and **G. Leimbach.** (Phys. Zeitschr. III. pp. 609–705, Aug. 15, 1902.)—The authors discuss a method of investigating the earth's crust by (1) reflection, and (2) absorption of electric waves sent through the rock strata. In the first method a slanting antenna is erected at some definite point on the earth's surface. Electric waves sent out therefrom pass through the earth, are reflected at the surface of any medium whose dielectric constant differs markedly from that of its surroundings, and are finally received by sloping antennæ at other points on the earth's surface. Maximum effects are obtained at a receiving station for two values of the inclination of the antenna—one corresponds to the direct, the other to the reflected waves. The positions of the wave-front of the reflected waves enables the situation of the reflecting surface to be determined. The method is effective in locating the surface of ground-water, coal seams, and metalliferous strata. In the second method vertical antennæ, 100 m. long, are used in borings about 300 m. deep and at any distances up to 400 km. apart. Experiments are then made to determine in which cases the electric waves can pass through the earth's crust, and in which they are lost by reflection and absorption by certain intervening media. The paper gives an account of the theory of the methods and of various experimental applications which have been made. The authors consider the methods will be useful in locating underground water in arid districts. A. D. R.

ÆTHERFORCE

Earth-Currents

In Mr. W. H. Preece's communication concerning the earth-currents which occurred on the 24th and 25th of last October in England, published in your issue of the 3rd of November, just come to hand, he says: "This is only a sample of what occurred simultaneously all over England, and probably the globe."

The following few extracts from the Log of the Madras-Bombay Lines show what was taking place out here:—

"Oct. 24, 22 hours, working Bellary with great difficulty. Severe lightning taps on instrument every now and then."

"Oct. 25, 8 hours, strong earth-currents at times.—17 hours 17.45 hours, very strong earth-currents.—22 hours, working Bombay with frequent stoppages, owing to strong earth-currents and failure of signals." Such is the character of the throughout the 24th and 25th of October.

ACCORDING to a telegram from New York, one of the finest displays of the aurora borealis ever known in that latitude was observed on the evening of February 13. The phenomenon stretched over a great belt of territory from Iowa to the Atlantic. A peculiar effect was produced on the telegraph system, and for intervals of three or four minutes at a time the wires were so surcharged with atmospheric electricity that between New York and Albany it was possible to send messages without the aid of the regular batteries. The current, however, was intermittent, and the effect unsatisfactory. For nearly two hours ordinary business could not be transacted with any degree of exactness. The aurora seemed to occupy the whole of the northern heavens, and was beautifully marked, the colouring being clear and distinct. People at first feared that a great fire was raging.

NATURE [FEBRUARY 18, 1892

A VIOLENT thunderstorm occurred on Ben Nevis last week from 11 p.m. of Friday to 2 a.m. of Saturday, St. Elmo's fire appearing there at the same time. During another thunderstorm on Saturday afternoon flashes came off from the telegraph wire connections inside the observatory; and about the same time a fire-ball was seen to strike the ground near the foot of the hill. The hygrometric fluctuations at the time were remarkable.

NO. 1237, VOL. 48]

JULY 13, 1893] NATURE

The English papers publish the following letter, in relation to the recent magnetic storm, from Professor Airy, the Astronomer Royal:—

"ROYAL OBSERVATORY,
"Greenwich, Aug. 5—12 M.

"DEAR SIR:—At the date of my letter yesterday the magnetic storm had somewhat subsided. Very soon, however, there were signs of great activity, and by 11 o'clock of last night (Friday, August 4th), the magnetic storm was sensibly as violent as before, and continued so through all the early morning hours. It has declined a little through the morning, but at the present time (Saturday, August 5, at noon) it is still very active.

"The spontaneous earth currents were not quite so strong in the last twenty-four hours (ending Saturday, August 5, at noon) as in the preceding twenty-four hours (ending Friday, August 4, at noon), but they are still very active. A nearly continuous register is made by the currents on the Dartford wire (which at first were not very strong) to midnight of Friday, August 4; but since that time the traces have been lost, and the currents on the Croydon wire have been very violent; only for a short time, ending about Friday, August 4, at 3 P. M., was the motion sufficiently gentle to have left any record, and then imperfectly. After that time the currents were so violent that the trace is totally lost.

"It is scarce in possibility that a telegraph current can have passed along the Atlantic cable in a legible state during any part of this time. "G. B. AIRY.

"G. SAWARD, Esq."

[An earthquake may affect a galvanometer or magnetic needle simply by magnetic or electrical disturbances, which generally accompany such a phenomenon, without any reference to the battery whatever, and this is a sufficiently good explanation of the apparent change in "quantity" and "intensity" mentioned in our correspondent's letter. We should be glad if Mr. Bottomley will kindly explain what he means by inorganic and organic batteries, and whether any of the cells he has experimented with would keep up a constant electromotive force for any length of time. We think that the changes noticed may have been independent of earthquakes.—EDS. ELEC. REV.]

SEPTEMBER 29, 1883.] THE TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW.

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(3.) LETTER FROM MR. THOMAS F. CLARK.

EXECUTIVE OFFICE.
INTERNATIONAL OCEAN TELEGRAPH COMPANY.
No. 195 BROADWAY, NEW YORK, Aug. 24, 1892.

CLEVELAND ABBE, Esq.,
Associate Editor, "American Meteorological Journal:"

Dear Sir,—Your esteemed favor of July 20, asking me for a statement of the effect of the electrical storms upon the cables of this company in July, was duly received, and I referred it to our cable manager at Key West for report. His absence from home has delayed his reply. I now, however, beg to send you the following extracts from the diaries of our offices at Punta Rassa, Fla., Key West, Fla., and Havana, Cuba, which I trust will be of service:—

"PUNTA RASSA, July 16.

"12.30 P. M. both cable circuits opened south for three minutes, then Key West and Havana signals reached here very unsteady, quick changes from strong to light currents; impossible to work the duplex circuit. Changed to single circuit, but signals very unsteady and at times circuit completely open. This lasted all the afternoon and evening, interfering greatly with exchange of signals."

"KEY WEST, July 16.

"2.15 to 2.30 P. M. could not work duplex circuit owing to strong earth currents coming and going at quick intervals. Also experienced great difficulty in working the circuit single. This lasted all the afternoon and evening. At times could only work the circuit by shutting off our regular battery current and utilizing the earth currents."

"HAVANA, CUBA.

"Reports same effects noticed there, and that the Cuba Sub-Marine Company's cables between Havana and Santiago de Cuba were so seriously influenced that all traffic was suspended. NOTE.—This latter company uses the 'mirror flash' instruments, which are more easily influenced by irregular earth currents than the Morse system (as used by us) would be. Therefore, it is highly probable that the unusual currents experienced south of Havana were not more severe than what was felt between Havana, Key West, and Punta Rassa. I am unable to say whether the currents experienced were positive or negative, coming out of the cables, but from what I can learn from the operators judge THAT REVERSALS were frequent. There was nothing unusual experienced on the fifteenth or seventeenth."

Yours truly,

THOS. F. CLARK, *Secretary.*

ÆTHERFORCE

How Aurora Borealis Affects Telegraph and Cable Lines

Here for the first time, are told the inside facts of just how the "Aurora Borealis" affects telephone and telegraph lines, as well as ocean cables. The facts presented are from the records of a leading American electrical engineer who has been in a position, fortunately, to carry on official observations and tests on this little understood phenomenon for many years.

THE Aurora Borealis, commonly called the "Northern Lights," pays us a visit now and then, the last severe attack on telegraph and telephone circuits, as well as ocean cables, having occurred on August 9th. The display was both spectacular and demoralizing to man-made electric communication lines. A few words on this remarkable phenomenon and its origin, which is now thought to be due to sun-spots, should be of interest.

"Since a magnetic storm of the intensity of that of August 9th demonstrably has power to arrest the operation over a whole continent and a whole ocean of telegraph, cable and telephone lines, how much more intense would a similar storm have to be in order to stop the engines of prowling submarines and of soaring aeroplanes, which in one case directly and in the other indirectly depend for their functioning on electricity? The source of the disturbance is in the sun, which exercises its power of interference from a distance of 93,000,000 miles" says a well-known scientist.

"In these questions lies the new significance of such a magnetic storm as that of August 9th, which occurred coincidentally with the existence on the sun of a vast disturbance that broke up millions of square miles of its fiery surface.

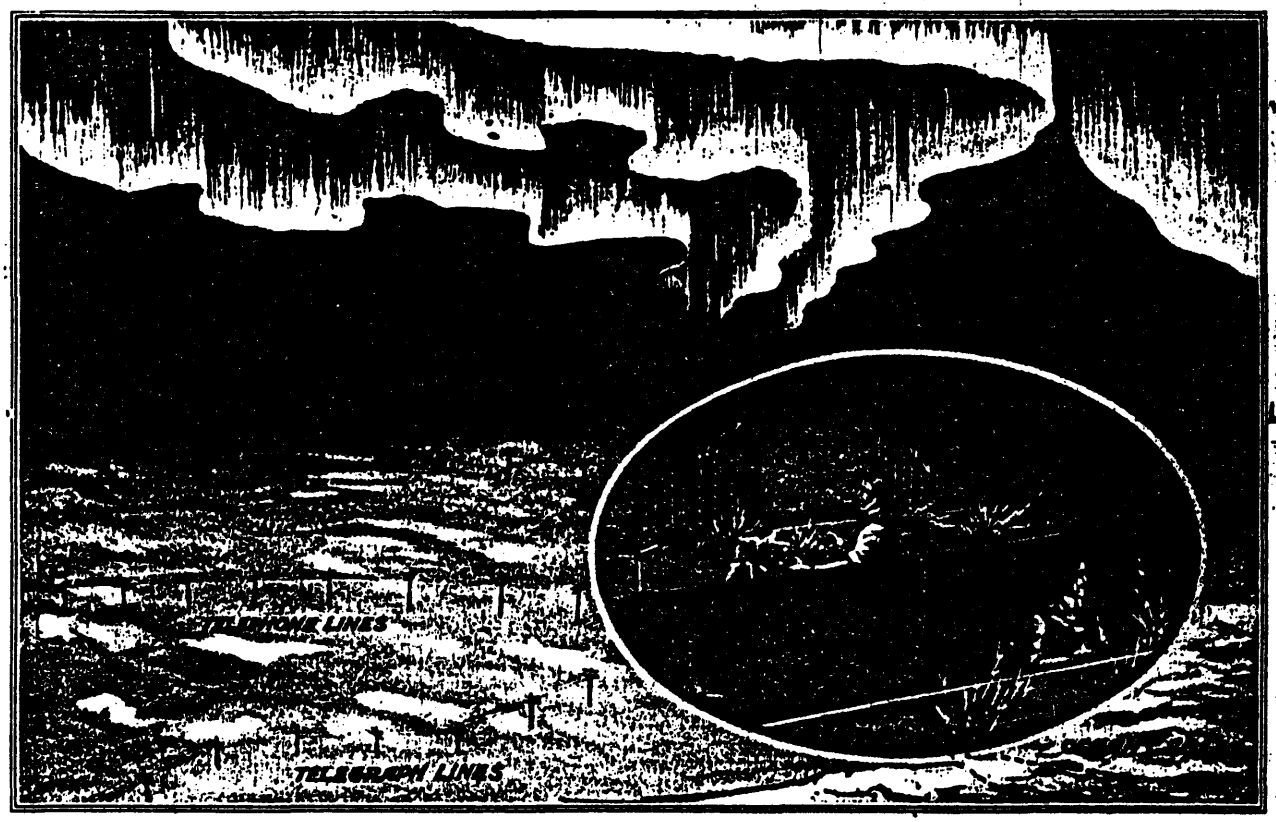
"The force of that disturbance, as it reached the earth, perhaps in the form of torrents of electrons, was only sufficient to be noticed in its effect, thru the magnetic currents of the earth, upon delicately balanced energies in electro-magnetic instruments; but imagine it magnified ten times or a hundred times, and then what? Sun-spots and their repercussion upon the earth have only been studied for a few decades, and it is but a few years since we first came into possession of instruments and engines depending on electricity for their action, so that we have not yet experimental knowledge of what the maximum of this solar explosive influence upon them may be.

"There are various theories concerning the precise manner in which the solar influence is transformed to the earth. One of the most probable supposes it to be done thru shafts of invisible radiations, resembling the cathode rays, which come from the sun, and, upon meeting the atmosphere, alter the conductivity of the upper strata and thus stimulate the circulation of aerial electric currents. The shafts of radiation, or of electrons, arise from centres of violent disturbance on the sun's surface."

A good explanation is given by the famous French astronomer—Camille Flammarion, who explains in *L'Illustration* that these northern lights are caused by the feverish condition of the sun. It seems as if the face of the sun had broken out in a fearful rash, so numerous and so large are the spots that have been observed, some even large enough to be seen with the naked eye.

"The sun," writes Flammarion, "is always a furnace of inconceivable physical and chemical phenomena, bombardments of electrified particles and enormous eruptions of gas, of which we can gain no idea even from the thunder-bolts of heaven which flash in lightning from the clouds, nor from the thunders of man which escape from the monstrous throats of cannon. These spots on the sun are actually at least 158,000 miles in diameter. Our earth is about 8,000 miles in diameter, so it could fall into one of them and be lost."

The great streamers of light that flickered over the northern sky, like the rays of giant searchlights, on many evenings in August and September were, according to Flammarion, radiations of electric light directly from the vast volcanoes and fiery tornadoes that are torturing the face of the sun. And these radiations extend out as far as the orbit of Neptune, more than 2,793,000,000 miles away!



The "Aurora Borealis" Visits Us Every Now and Then, the Last One Having Occurred on August 9, 1917. At These Times There are Severe Electrical Disturbances Set Up on Telephone and Telegraph as Well as Cable Lines. Transient Electric Currents Often Surge Thru the Circuits, Which Register a Potential of Several Hundred Volts.

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technical society a piece of apparatus, shown in the illustration, which, when connected in circuit with a telegraph-line, will show the varying strength of the current in the line, registering the results on a diagram. The earth-currents are generally very weak, and only can be

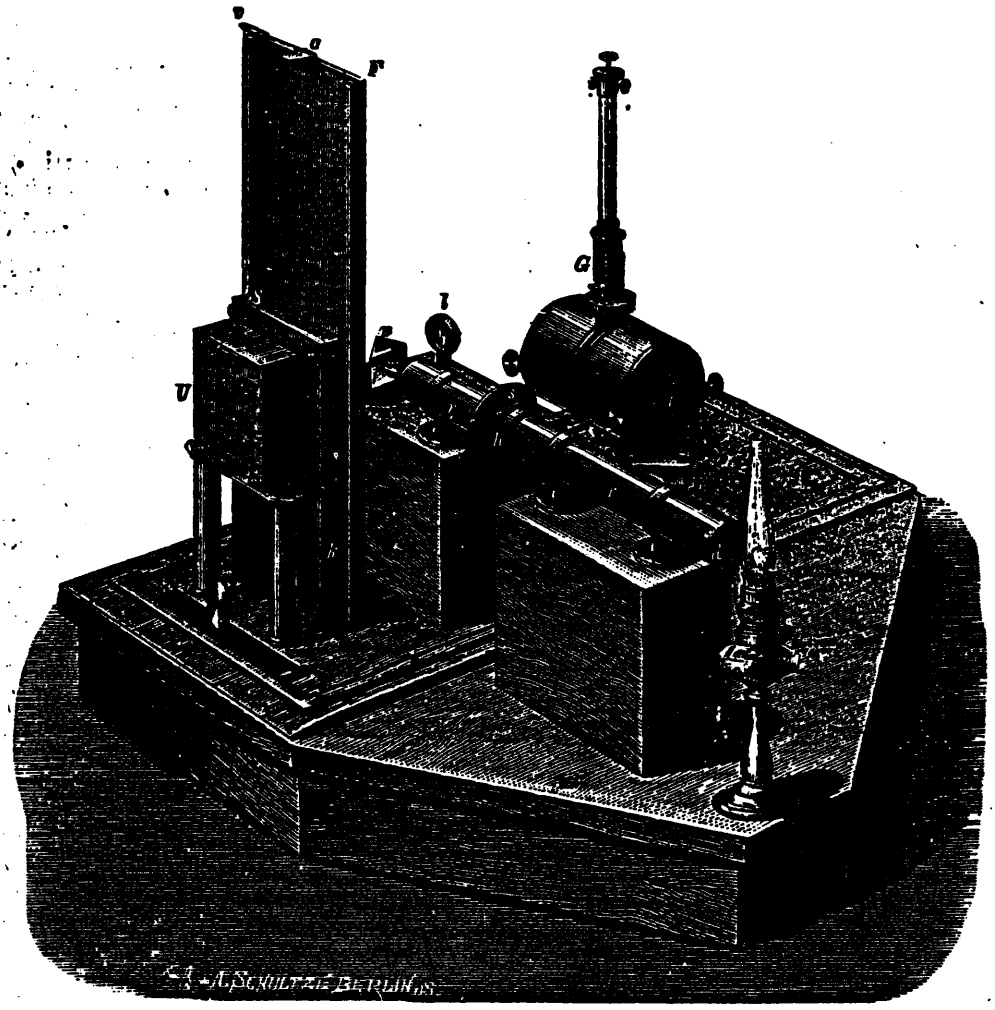

Fig. 1.

REGISTERING APPARATUS FOR EARTH-CURRENTS.[1]

For the purpose of studying the earth-currents on telegraph-lines, the instrument-maker, Wauschaff of Berlin, has made for the earth-current committee of the German electro-

[1] From the April number of *Zeitschrift für instrumentenkunde.*

shown by the most delicate galvanometers, so that no registering apparatus requiring a great amount of force could be used. This necessitated the use of photography. That the observations might be independent of the hour of the day, an artificial source of light was used. The most sensitive dry plates were employed, and, to keep out all extraneous light, the

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whole apparatus is covered with a wooden box, removed in the illustration. This cover turns on the hinges at *c*, and, when closed, rests in the grooves *f*. The tubes *r* and *r'* are furnished with two cloth-lined metal collars, which can be pressed up against the box where the tubes pass through it. The outer end of *r* is closed with a plate in which there are three round holes side by side in a horizontal line. Before this plate is the diaphragm *d*, which can be turned on a vertical axis, and through which there is one hole. With this diaphragm the central opening in the end of *r* may be alone left open. In front is placed a kerosene lamp. From the flame of this lamp a fine pencil of rays passes through the hole in *d*, along the tubes *r* and *r'*, and is reflected by a total reflecting-prism, *p*, which throws it on the mirror, *G*, of the galvanometer, which is connected in circuit with the line by the wires *z*. From the mirror *G* the light is reflected back through the lens *l*, which brings the rays to a focus on the photographic plate. This plate is put in a holder, *k*, in the slide *S*, before the beginning of the observation. There are spring clamps on *S*, so that, when the cover is drawn from in front of the plate, the holder will remain in *S*. In order that it may be possible to expose the plate after the box-cover is put down, there is a slit covered with rubber cloth in the box, through which the fingers may reach the top of the plate-holder and pull out the sliding front. The slide *S* travels on guides *F*, and on one side is furnished with two rollers, and on the other with one; so that the movement may be as straight as the guide against which the two rollers press. In the front-side of *F* there is a horizontal slit at the height of the focus of the rays. The back side of *S* carries a rack which fits a pinion on the driving-axis of the clock *U*. The downward movement of *S* is therefore regulated by this clock, of which it forms the driving-weight. The downward velocity is about 80 mm. per hour. This is sufficient to allow of changes from minute to minute being easily distinguished. For the purpose of allowing different rates of speed, it is proposed to put another rack on the back of *S*, which, by a sliding motion, may be made to catch on a second pinion of different size. For lesser changes the pendulum may be varied in length.

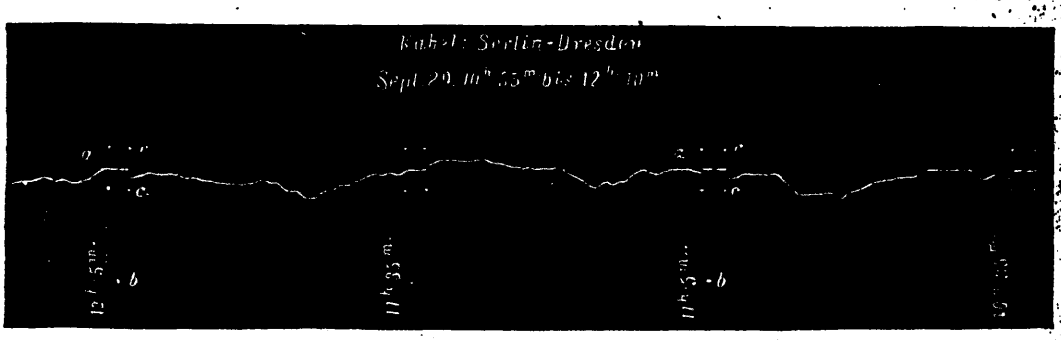

FIG. 2.

The wires leading to the galvanometer are connected with a commutator. When the needle is in its position of rest, a straight line will be marked on the plate by an upward movement of the slide. From this line the deflections caused when the earth-currents pass are measured. Time-signals may be made by turning back the diaphragm *d*, when marks will be made on each side of the neutral line. From time to time, currents of known strength may be sent through the apparatus, and will produce spots, as *b*.

Fig. 2 shows one of the diagrams obtained. The abscissa line was drawn through the portions *a*, which were marked by the light. The portions *a* are broken, and at these points occur the dots *b*, the result of the known currents. *c*, *c* are the time-signals.

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Electrical Engineer.

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RECENT OBSERVATIONS ON EARTH CURRENTS.

BY

THE working of telegraph lines extending in an easterly and westerly direction was greatly affected by the magnetic storm of Aug. 19 and 20 which was accompanied by displays of brilliant auroræ observed in various sections of the country. The disturbance was first observed about 9 P. M. on Sunday Aug. 19, when the wires began to work badly, and become so intense at frequent intervals throughout the night as to render circuits useless, not only on land lines but on submarine wires as well. The storm, which exhibited many of the ordinary characteristics of such phenomena, did not finally disappear until after 5 P. M., Monday, Aug. 20, though its effects after 9 o'clock on the morning of that day were not very marked east of Chicago; but they were sufficiently pronounced on lines west of that point to cause temporary stoppage of work, especially on automatic and quadruplex circuits.

Similar phenomena were noted on July 20, and the disturbance which was first felt about 5.20 A. M., assumed a wave-like character which reached its highest altitude with almost perfect regularity about once every two hours until 7.30 P. M., when the storm so far subsided as to leave the working of land lines unaffected.

The ebb and flow of the earth currents during the prevalence of the storm were generally characterized with remarkable steadiness and deliberation, forming a strong contrast to the violent fluctuations of many preceding magnetic storms, one of which exhibited no fewer than 150 variations in the magnitude and polarity of its currents in the course of a single minute. An interesting practical point in this connection consists in the fact that whereas land lines are invariably influenced by either of these classes of earth current, provided the latter is sufficiently strong, the submarine cables do not seriously feel the effects of a very gradual variation of current.

It frequently happens that the Atlantic and other cables enjoy comparative immunity from earth current interruptions at times when land lines are more or less prostrated; while at other times the cable circuits have suffered from comparatively weak but fluctuating currents that had no practical influence upon the working of aerial wires. This anomalous action arises from the fact that condensers are interposed in cable circuits, which are operated, not by continuous currents as in the case of land lines, but by induced currents of momentary duration produced by the charging and discharging of the condensers. The latter being responsive only to sudden variations in current strength, it will be evident that such apparatus serves to exclude from the cables all but the more variable class of currents, which latter, however, affect the cable irrespective of the current value.

The storm of July 20 did not apparently pursue the usual easterly and westerly direction, but took a course more nearly N. N. W. judging from the results of a number of simultaneous observations taken on different wires with the view of determining the line of maximum disturbance. The greatest difference of potential discovered on any wire on that occasion was 62 volts, but from indications noted at times when it was found impracticable to take scientific measurements, it was evident that the electromotive force developed in some circuits amounted to upwards of 150 volts.

From the result of other tests, the writer was able to practically demonstrate that the difference of potential established between the ends of any wire is directly proportional to the *geographical* length of its circuit; or in other words, the electrical pressure developed is not determined by the actual course taken by the wires, but by that of a straight line, drawn from one extremity or ground connection to the other.

This statement, which might otherwise appear so self-evident as to be superfluous, is intended to emphasize the fact that the distance between any two points on the earth's surface is so small compared with the distance between the sun and earth, that the law of inverse squares as ordinarily applied to electric forces is practically reduced to one in which the E. M. F. developed in any conductor is directly proportional to the shortest distance between its terminals.

Sun spots are generally credited with being the cause of earth currents, and it is a fact within the writer's knowledge and experience that no magnetic storm of any magnitude has ever appeared without its accompanying solar disturbance; but it is equally a fact that the two phenomena are not invariably associated with each other, inasmuch as groups of prominent sun spots have oftentimes been visible upon the sun's disc when earth currents have been conspicuous by their absence.

This circumstance would appear to confirm the views held by Dr. M. A. Veeder who has made a study of the subject, and who is in possession of data which apparently prove that magnetic storms are only possible when the spots are in a particular locality and when the earth occupies a certain position in relation to those spots.

He further contends that the effects produced are brought about by *conduction* rather than by *induction*, and that the masses of matter thrown off from the sun when the latter is violently agitated, constitute the medium through which the electrical energy is transmitted from the sun to the earth, as otherwise the presence of earth currents ought to be felt whenever and wherever sun spots are visible, if the latter are to be regarded as the direct cause of terrestrial magnetic phenomena.

The subject is one of considerable scientific interest, and is at present engaging the attention of scientists throughout the civilized world, a great number of whom are in direct communication with Dr. Veeder on the subject. Through the courtesy of General Eckert, President and General Manager of the Western Union Telegraph Co., observations are now being taken on that company's lines which it is hoped will be of service in aiding such investigations.

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EXTRACTS FROM AN ADDRESS BY SIR W. THOMSON, TO THE SOCIETY OF TELEGRAPHIC ENGINEERS

I HAVE advisedly, not thoughtlessly, used the expression "terrestrial electricity." It is not an expression we are accustomed to. We are accustomed to "terrestrial magnetism;" we are accustomed to atmospheric electricity. The electric telegraph forces us to combine our ideas with reference to terrestrial magnetism and atmospheric electricity. We must look upon the earth and the air as a whole—a globe of earth and air—and consider its electricity whether in rest or in motion. Then, as to terrestrial magnetism, of what its relation may be to perceptible electric manifestations we at present know nothing.

You all know that the earth acts as a great magnet. Dr. Gilbert, of Colchester, made that clear nearly 300 years ago; but how the earth acts as a great magnet—how it is a magnet,—whether an electro-magnet in virtue of currents revolving round under the upper surface, or whether it is a magnet like a mass of steel or load-stone, we do not know. This we do know, that it is a variable magnet, and that a first approximation to the variation consists in a statement of motion round the axis of figure—motion of the magnetic poles, round the axis of figure, in a period of from 900 to 1,000 years. The earth is not a uniformly magnetised magnet with two poles, and with circles of symmetry round those poles. But a first expression—as we should say in mathematical language the first "harmonic term"—in the full expression of terrestrial magnetism is an expression of a regular and symmetrical distribution such as I have indicated. Now, this is quite certain, that the axis of this first term, so to speak, or this first approximation, which, in fact, we might call the magnetic axis of the earth, does revolve round the axis of figure.

When the phenomena of terrestrial magnetism were first somewhat accurately observed about three hundred years ago, the needle pointed here in England a little to the east of north; a few years later it pointed due north; then, until about the year 1820, it went to the west of north; and now it has come back towards the north. The dip has experienced corresponding variations. The dip was first discovered by the instrument maker, Robert Norman, an illustration, I may mention in passing, of the benefits which abstract science derives from practical applications—one of the most important fundamental discoveries of magnetism brought back to theory by an instrument maker who made mariner's compasses. Robert Norman, in balancing his compass cards, noticed that after they were magnetised one end dipped, and he examined the phemonenon and supported a needle about the centre of gravity, magnetised it, and discovered the dip. When the dip was first so discovered by Robert Norman it was less than it is now. The dip has gone on increasing, and is still increasing; but about 50 years ago the deviation from true north was greatest. Everything goes on as if the earth had a magnetic pole revolving from west to east round the true North Pole, at a distance of 20° from it. About three hundred years ago its azimuth from England was a little to the east of the north pole: then it came round, moving eastwards on the far side of the north pole, and round in a circle towards us on the left-hand side of the north pole, as looked to from England. That motion in a circle round the north pole has already been experienced within the period during which somewhat accurate measurements have been made—has been experienced to the extent of rather more than a quarter of the whole revolution; and we may expect that about 200 years from the present time the magnetic pole will be between England and the North Pole; so that the needle will thus point due north, and the dip be greater than it has been for 1,000 years, or will be for another. It is one of the greatest mysteries of science, a mystery which I might almost say is to myself a subject of daily contemplation—what can be the cause of this magnetism in the interior of the earth? Rigid magnetisation, like that of steel or the load-stone, has no quality in itself in virtue of which we can conceive it to migrate round in the magnetised bar. Electric currents afford the more favoured hypothesis; they are more mobile. If we can conceive electric currents at all, we may conceive them flitting about. But what sustains the electric currents? People sometimes say, heedlessly or ignorantly, that thermo-electricity does it. We have none of the elements of the problem of thermo-electricity in the state of underground temperature which could possibly explain, in accordance with any knowledge we have of thermo-electricity, how there could so be sustained currents round the earth. And if there were currents round the earth, regulated by some cause so as to give them a definite direction at one time, we are as far as ever from explaining how the channel of those currents could experience that great secular variation which we know it does. Thus we have merely a mystery. It would be rash to suggest even an explanation. I may say that one explanation has been suggested. It was suggested by the great astronomer, Halley, that there is a nucleus in the interior of the earth, and that the mystery is explained simply by a magnet not rigidly connected with the upper crust of the earth, but revolving round an axis differing from the axis of rotation of the outer crust, and exhibiting a gradual precessional motion independent of the precessional motion of the outer rigid crust. I merely say that has been suggested. I do not ask you to judge of the probability: I would not ask myself to judge of the probability of it. No other explanation has been suggested.

But now, I say, we look with hopefulness to the practical telegraphist for data towards a solution of this grand problem. The terrestrial magnet is subject, as a whole, to the grand secular variation which I have indicated. But, besides that, there are

* Since the first notices of this lecture appeared in the newspapers, strong confirmatory evidence has been received.

† The foregoing report was compiled from the notes of Prof. Tyndall. It is published with Prof. Tyndall's sanction, but was not written by himself.

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annual variations and diurnal variations. Every day the needle varies from a few minutes on one side to a few minutes on the other side of its mean position, and at times there are much greater variations. What are called "magnetic storms" are of not very unfrequent occurrence. In a magnetic storm the needle will often fly twenty minutes, thirty minutes, a degree, or even as much as two or three degrees sometimes, from its proper position—if I may use that term—its proper position for the time; that is, the position which it might be expected to have at the time according to the statistics of previous observations. I speak of the needle in general. The ordinary observation of the horizontal needle shows these phenomena. So does observation on the dip of the needle. So does observation on the total intensity of the terrestrial magnetic force.

The three elements, deflection, dip, and total intensity, all vary every day with the ordinary diurnal variation, and irregularly with the magnetic storm. The magnetic storm is always associated with a visible phenomenon, which we call, habitually, electrical;—aurora borealis, and, no doubt, also aurora of the southern polar regions. We have the strongest possible reasons for believing that aurora consists of electric currents, like the electric phenomena presented by currents of electricity through what are called vacuum tubes, through the space occupied by vacuums of different qualities in the well-known vacuum tubes. Of course, the very expression, "vacuums of different qualities" is a contradiction in terms. It implies that there are small quantities of matter of different kinds left in those nearest approaches to a perfect vacuum which we can make.

Well now, it is known to you all that aurora borealis is properly comparable with the phenomena presented by vacuum tubes. The appearance of the light, the variations which it presents, and the magnetic accompaniments, are all confirmatory of this view, so that we may accept it as one of the truths of science. Well now—and here is a point upon which, I think, the practical telegraphist not only can, but will, before long give to abstract science data for judging—is the deflection of the needle a direct effect of the auroral current, or are the auroral current and the deflection of the needle common results of another cause?

With reference to this point, I must speak of underground currents. There again I have named a household word to everyone who has anything to do with the operation of working the electric telegraph, and not a very pleasing household word I must say. I am sure most practical telegraphers would rather never hear of earth currents again. Still we have got earth currents; let us make the best of them. They are always with us; let us see whether we cannot make something of them, since they have given us so much trouble. Now, if we could have simultaneous observations of the underground currents, of the three magnetic elements, and of the aurora, we should have a mass of evidence from which, I believe, without fail, we ought to be able to conclude an answer more or less definite to the question I have put. Are we to look in the regions external to our atmosphere for the cause of the underground currents, or are we to look under the earth for some unknown cause affecting terrestrial magnetism, and giving rise to an induction of those currents? The direction of the effects, if we can only observe those directions, will help us most materially to judge as to what answer should be given.

It is my desire to make a suggestion which may reach members of this society, and associates in distant parts of the world. I make it not merely to occupy a little time in an inaugural address, but with the most earnest desire and expectation that something may be done in the direction of my suggestion. I do not venture to say that something may come from my suggestion, because, perhaps, without any suggestion from me, the acute and intelligent operators whom our great submarine telegraph companies have spread far and wide over the earth, are fully alive to the importance of such observations as I am now speaking of. I would just briefly say that this kind of observation is what would be of value for the scientific problem—to observe the indication of an electrometer at each end of a telegraph line at any time, whether during a magnetic storm or not, and at any time of the night or day. If the line be worked with a condenser at each end, this observation can be made without in the slightest degree influencing, and therefore without in the slightest degree disturbing, the practical work throughout the line. Put on an electrometer in direct connection with the line, connect the outside of the electrometer with a proper earth connection, and it may be observed quite irrespectively of the signalling; when the signalling is done, as it very frequently is at submarine lines with a condenser at each end. The scientific observation will be disturbed undoubtedly, and considerably disturbed by the sending of messages, but the disturbance is only transient, and in the very pause at the end of a word there will be a sufficiently near approach to steadiness in the potential at the end of a wire connected with the electrometer to allow a careful observer to estimate with practical accuracy the indication that he would have were there no working of the line going on at the time. A magnetic storm of considerable intensity does not stop the working, does indeed scarcely interfere with the working, of a submarine line in many instances when a condenser is used at each end.

Thus, observations, even when the line is working, may be made during magnetic storms, and again, during hours when the line is not working, if there are any, and even the very busiest lines have occasional hours of rest. Perhaps, then, however, the operators have no time or zeal left, or, rather, I am sure they have always zeal, but I am not sure that there is always time left, and it may be impossible for them to bear the strain longer than their office hours require them. But when there is an operator, or a superintendent, or a mechanic, or an extra operator who may have a little time on his hands, then, I say, any single observation or any series of observations that he can make on the electric potentials at one end of an insulated line will give valuable results. When arrangements can be made for simultaneous observations of the potentials by an electrometer at the two ends of the line, the results will be still more valuable.

And, lastly, I may just say that when an electrometer is not available, a galvanometer of very large resistance may be employed. This will not in the slightest degree interfere with the practical working any more than would an electrometer, nor will it be more difficult to get results of the scientific observations not overpoweringly disturbed by the practical working if a galvanometer is used than when an electrometer is available. The more resistance that can be put in between the cable and the earth in circuit with the galvanometer the better, and the sensibility of the galvanometer will still be found perhaps more than necessary. Then, instead of reducing it by a shunt, let steel magnets, giving a more powerful direction to the needle, be applied for adjusting it. The resistance in circuit with the galvanometer between cable-end and earth ought to be at least twenty-times the cable's copper-resistance to make the galvanometer observations as valuable as those to be had by electrometer.

I should speak also of the subject of atmospheric electricity. The electric telegraph brings this phenomenon into connection with terrestrial magnetism with earth currents, and through them with aurora borealis, in a manner for which observations made before the time of the electric telegraph, or without the aid of the electric telegraph, had not given us any data whatever. Scientific observations on terrestrial magnetism, and on the aurora, and on atmospheric electricity, had shown a connection between the aurora and terrestrial magnetism in the shape of the disturbances that I have alluded to at the time of magnetic storms; but no connection between magnetic storms and atmospheric electricity, thunderstorms, or generally the state of the weather—what is commonly called meteorology—has yet been discovered.

The one common link connecting these phenomena hitherto known to us is exhibited in the electric telegraph. A telegraphic line—an air line more particularly, but a submarine line also—shows us unusually great disturbances, not only when there are auroras and variations of terrestrial magnetism, but when the atmospheric electricity is in a disturbed state. That it should be so electricians here present will readily understand. They will understand when they consider the change of electrification of the earth's surface which a lightning discharge necessarily produces.

I fear I might occupy too much of your time, or else I would just like to say a word upon atmospheric electricity, and to call your attention to the quantitative relations which questions in connection with this subject bear to those of ordinary earth currents and the phenomena of terrestrial magnetism. In fair weather, the surface of the earth is always, in these countries at all events, found negatively electrified. Now the limitation to these countries that I have made suggests a point for the practical telegraphists all over the world. Let us know whether it is only in England, France, and Italy that in fine weather the earth's surface is negatively electrified.

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The only case of exception on record to this statement is Prof. Piazzi Smyth's observations on the Peak of Teneriffe. There, during several months of perfectly fair weather, the surface of the mountain was, if the electric test applied was correct, positively electrified; but Prof. Piazzi Smyth has, I believe, pointed out that the observations must not be relied upon. The instrument, as he himself found, was not satisfactory. The science of observing the atmospheric electricity was then so much in its infancy that, though he went prepared with the best instrument, and the only existing rules for using it, there was a fatal doubt as to whether the electricity was positive or negative after all. But the fact that there has been such a doubt is important. Now I suppose there will be a telegraph to Teneriffe before long, and then I hope and trust some of the operators will find time to climb the Peak. I am sure that, even without an electric object, they will go up the Peak. Now they must go up the Peak with an electrometer in fine weather, and ascertain whether the earth is positively or negatively electrified. If they find that on one fine day it is negatively electrified, the result will be valuable to science; and if on several days it is found to be all day and all night negatively electrified, then there will be a very great accession to our knowledge regarding atmospheric electricity.

When I say the surface of the earth is negatively electrified, I make a statement which I believe was due originally to Peltier. The more common form of statement is that the air is positively electrified, but this form of statement is apt to be delusive. More than that, it is most delusive in many published treatises, both in books and encyclopædias upon the subject. I have in my mind one encyclopædia in which, in the article "Air, Electricity of," it is said that the electricity of the air is positive, and increases in rising from the ground. In the same encyclopædia, in the article "Electricity, Atmospheric," it is stated that the surface of the earth is negatively electrified, and that the air in contact with the earth, and for some height above the earth, is, in general, negatively electrified. I do not say too much, then, when I say that the statement that the air is positively electrified has been at all events a subject for ambiguous and contradictory propositions; in fact, what we know by direct observation is, that the surface of the earth is negatively electrified, and positive electrification of the air is merely inferential.

Suppose, for a moment, that there were no electricity whatever in the air—that the air were absolutely devoid of all electric manifestation, and that a charge of electricity were given to the whole earth. For this no great amount would be necessary. Such amounts as you deal with in your great submarine cables would, if given to the earth as a whole, produce a very considerable electrification of its whole surface. You all know the comparison between the electricity of one Atlantic cable—the electro-static capacity of one of the Atlantic cables—with the water round its gutta-percha for outer coating, and the earth and air with infinite space for its outer coating.* I do not remember the figures at this moment; in fact, I do not remember which is the greater. Well, now, if all space were non-conducting—and experiments on vacuum tubes seem rather to support the possibility of that being the correct view—if all space were non-conducting, our atmosphere being a non-conductor, and the rarer and rarer air above us being a non-conductor, and the so-called vacuous space, or the interplanetary space beyond that (which we cannot admit to be really vacuous) being a non-conductor also, then a charge could be given to the earth as a whole, if there were the other body to come and go away again, just as a charge could be given to a pith ball electrified in the air of this room. Then, I say, all the phenomena brought to light by atmospheric electrometers, which we observe on a fine day, would be observed just as they are. The ordinary observation of atmospheric electricity would give just the result that we obtain from it. The result that we obtain every day in observations on atmospheric electricity is precisely the same as if the earth were electrified negatively and the air had no electricity in it whatever.

Well, now I have asserted strongly that the lower regions of the air are negatively electrified. On what foundation is this assertion made? Simply by observation. It is a matter of fact; it is not a matter of speculation. I find that when air is drawn into a room from the outside, on a fine day, it is negatively electrified. I believe the same phenomena will be observed in this city as in the old buildings of the University of Glasgow, in the middle of a very densely-peopled and smoky part of Glasgow; and therefore I doubt not that when air is drawn into this room from the outside, and a water-dropping collector is placed in the centre of the room, or a few feet above the floor, and put in connection with a sufficiently delicate electrometer, it will indicate negative electrification. Take an electric machine; place a spirit-lamp on its prime conductor; turn the machine for a time; take an umbrella, and agitate the air with it till the whole is well mixed up; and keep turning the machine, with the spirit-lamp burning on its prime conductor. Then apply your electric test, and you find the air positively electrified.

Again—Let two rooms, with a door and passage between them, be used for the experiment. First shut the door and open the window in your observing room. Then, whatever electric observations you may have been performing, after a short time you find indications of negative electrification of the air. Then, during all that time, let us suppose that an electric machine has been turned in the neighbouring room, and a spirit-lamp burning on its prime conductor. Keep turning the electric machine in the neighbouring room, with the spirit-lamp as before. Make no other difference but this—shut the window and open the door. I am supposing that there is a fire in your experimenting room. Then, when the window was open and the door closed, the fire drew its air from the window, and you got the air direct from without. Now shut the window and open the door into the next room, and gradually the electric manifestation changes. And here somebody may suggest that it is changed because of the opening of the door and the inductive effect from the passage. But I anticipate that criticism by saying that my observation has told me that the change takes place gradually. For a time after the door is opened and the window closed, the electrification of the air in your experimenting room continues negative, but it gradually becomes zero, and a little later becomes positive. It remains positive as long as you keep turning the electric machine in the other room and the door is open. If you stop turning the electric machine, then, after a considerable time, the manifestation changes once more to the negative; or if you shut the door and open the window the manifestation changes more rapidly to negative.

It is, then, proved beyond all doubt that the electricity which comes in at the windows of an ordinary room in town is ordinarily negative in fair weather. It is not always negative, however. I have found it positive on some days. In broken weather, rainy weather, and so on, it is sometimes positive and sometimes negative. Now, hitherto, there is no proof of positive electricity in the air at all in fine weather; but we have grounds for inferring that probably there is positive electricity in the upper regions of the air. To answer that question the direct manner is to go up in a balloon, but that takes us beyond telegraphic regions, and therefore I must say nothing on that point. But I do say that superintendents and telegraph operators in various stations might sometimes make observations; and I do hope that the companies will so arrange their work, and provide such means for their spending their spare time, that each telegraph-station may be a sub-section of the Society of Telegraph Engineers, and may be able to have meetings, and make experiments, and put their forces together to endeavour to arrive at the truth. If telegraph operators would repeat such experiments in various parts of the world, they would give us most valuable information.

And we may hope that besides definite information regarding atmospheric electricity, in which we are at present so very deficient, we shall also get towards that great mystery of nature—the explanation of terrestrial magnetism and its associated phenomena,—the grand secular variation of magnetism, the magnetic storms, and the aurora borealis.

* The earth's radius is about 630 million centimetres, and its electrostatic capacity is therefore 630 microfarads, or about that of 2,600 miles of cable.

ÆTHERFORCE

Meteorological Society, March 2.—Dr. Weinstein spoke on the earth's currents which were observable in the telegraph wires by the disturbances they caused in the message service, their intensity at times exceeding that of the batteries of eighty Daniell employed for telegraphing. In order to the observation of the earth's currents, two equal metal plates had since the time of Faraday been sunk into the ground and connected by a wire, in which a galvanometer was interpolated. The deviations of the galvanometer needle might be induced as well by an earth-current as by a current which arose from the contact of the earth-plates with the earth. In the latter case, however, the current would be very weak when the plates were at a great distance from each other. The case being, in point of fact, otherwise, however, the currents in question were accordingly earth-currents. The measurement of them was achieved by means of self-registering apparatus, either in the way of photography in England or mechanically in Germany, in the earth-current was conducted through a coil, that, suspended in the interval between a rod magnet and a hollow cylinder magnet, was, under the oscillations of the current, drawn in or pushed out, and, by means of a lever, inscribed these movements on soot-blackened paper. The direction of the current in the body of the earth was found by observation of two circuits forming a right angle with each other. In Berlin one circuit proceeded eastwards towards Thorn, the other southwards towards Dresden. The observations made in Berlin showed a direction of the earth's current from north-east to south-west, while in England the direction went more from north to south with a slight deviation towards the east, and in France a direction from north to south with an inclination towards the west was observed. The earth-current showed a perfectly regular daily variation. In the night the earth-current is slight; from 8 o'clock in the morning it regularly increases, attains its maximum precisely at 12 noon, thence sinks rapidly till 4 p.m., whence it continues uniformly weak, not to revive till the following morning. A course precisely analogous to that of the earth-current was manifested by the earth's magnetism, the connection of which with the electricity of the earth attracted attention from the very beginning, when disturbances made themselves observable. To demonstrate with perfect precision the coincidence of the two phenomena it was necessary to take for the purpose of comparison not a single earth-magnetic element, but the earth's total magnetism. The earth's electricity and the earth's magnetism showed, moreover, in their regular daily course, their affinity, by the simultaneity with which their disturbances occurred. This simultaneity was so precise that in one case the distance between Berlin and Wilhelmshaven could be determined from the time when the disturbance of the earth's current made itself felt in Berlin and the time when the magnetic disturbance occurred in Wilhelmshaven. This simultaneity of disturbances at distant points of the earth pointed to a cosmical cause. Thus in August last year, at the very time when in Paris the emergence of an altogether unusual solar protuberance was observed, a magnetic disturbance was registered in Petersburg, and a disturbance of the earth's current in Berlin. The earth's current and the earth's magnetism showed further in common the periods of eleven years which coincided with those of the solar spots. In respect of the earth's current, this period could not indeed be demonstrated to a certainty, seeing that the regular observations made respecting it were yet of too recent date; but the regular course of the oscillations warranted the conclusion of a like period being drawn. A period of from two to five days in which the earth's current and the earth's magnetism showed in their oscillations alternately larger and smaller amplitudes had, in addition, been detected, although the explanation of the phenomenon was not yet forthcoming. With reference to the question which phenomenon was the primary, the earth's current or the earth's magnetism, opposite views were entertained. The earth's electricity was assuredly not strong enough to magnetise the body of the earth; but, on the other hand, against the assumption that the earth's currents were induced by the oscillations of the earth's magnetism an objection might be raised, namely, that in such a case the earth's currents would have to be proportional to the velocities of the oscillations of the earth's magnetism, and not to the oscillations themselves. This question can only be decided by further observations and by experiment. In a wide circle out of telegraph circuits the induction effects of the earth's magnetism might be studied and compared with the earth's currents. The speaker discussed the different theories of the earth's electricity set forth by Faraday, De la Rive, Lamont, Edlund, and the Brothers William and Werner Siemens, without declaring himself decidedly in favour of any of them. In conclusion he drew attention to the series of different jerks which showed themselves in the self-registering curve of the earth's currents on the occasion of every thunderstorm. A jerk of this description on the part of the pointer seemed to correspond with each lightning-flash.

AETHERFORCE

On October 31, 1903, aurora borealis disturbances affected telegraph and telephone lines extending between Chicago and the eastern cities. On telegraph wires, without regular battery being applied at terminal offices, grounded lines showed a potential of 425 volts positive, varying to 225 volts negative; the disturbance continuing between 12:15 a. m., and 9:15 a. m.

Measurements were made with ordinary direct current voltmeters. The voltage readings were not constant or steady. The positive indication, for instance, would, during a period of 3 or 4 minutes, swing backward and forward in degrees between 200 and 425 volts. Once, however, the needle of the reversely connected voltmeter indicated negative potential; the potential increased rapidly up to 225 volts; varying then, between 100 and 225 volts negative.

The ohmic resistance of the lines was about 2,000 ohms; grounded at Chicago and Pittsburgh, Pa., and at Chicago and Buffalo, N. Y. This and the following report are presented thru the courtesy of Mr. Donald McNicol, assistant electrical engineer, Postal Telegraph Cable Company, who has given this subject much study.

With reference to earth currents and cables, the writer (Mr. McNicol) may be permitted to quote extracts from his official report of 1892, in connection with the trans-Atlantic determination of longitude. At that time there were ten cables across the Atlantic, but when earth currents set in they are not all equally disturbed; in fact, it happens that some of the cables are not affected at all. The French cable from Brest, France, to St. Pierre, Miquelon Island, (near New Foundland), seems to be disturbed the most, and again the disturbances are felt to a greater extent at St. Pierre than at Brest. It often happens that St. Pierre can send messages to Brest, but cannot receive any.

Long cables seem to be more affected than short ones, and, furthermore, the abnormal earth currents appear to travel mostly from *east to west*. When the aurora is visible, it is quite certain that earth currents will show themselves. Thunderstorms and they, however, do not seem to be so closely related, if, at all.

During the past season (1892), on July 16th, there was a remarkable disturbance noticed at Canso, Nova Scotia, stopping all work completely. The greatest "kick," as it is called, was given at 12:20 p. m., eastern standard time, or 5:20, Greenwich mean time. Some weeks afterwards reports came in the technical journals, from Brest, Malta, Cairo, Madras and east to Singapore of a similar disturbance on that day. Cairo, Egypt, fortunately stated the time, and from it, it was found to have been simultaneous with that of Canso.

On August 24 (1892), strong earth currents set in at Canso, and at the time there was a marked auroral display.

EARTH CURRENTS

IT has been my pleasure at different times to call attention to the connection that exists between the Auroræ Boreales and that great apparent rush of electricity through the crust of the earth which eagerly seizes upon the easy paths, offered to its passage by the wires of the telegraph, and by filling them with electricity, produces what are called "earth currents," or "deflections." The aurora is always accompanied by such displays, but it is rarely in England that they are of such strength as absolutely to break down telegraph communication. The earth currents of Oct. 24 and 25 have only been equalled by those which occurred in 1859.

The following extracts from the diary of one of the large telegraph stations in the South of England will be found interesting ;—

Oct. 24,	5.0 P.M.	Slight deflections on all long circuits.
"	5.30 "	Gradually increasing.
"	6.0 "	Very strong ; circuits suspended for ten minutes.
"	7.0 "	Gradually decreasing.
"	8.15 "	All circuits right.
Oct. 25,	3.0 "	Deflections, which have been intermittent all day, or very strong.
"	3.30 "	Circuits nearly all stopped.
"	4.0 "	Working through on some circuits, but slow.
"	5.0 "	Deflections decreasing.
"	5.45 "	On again; all circuits suspended.
"	6.15 "	Deflections decreasing again.
"	7.0 "	Circuits clear.

This is only a sample of what occurred simultaneously all over England, and probably the globe. The currents were very irregular in their direction and very variable in their strength. Circuits running S.W. to N.E. are usually most powerfully affected, but on this occasion all directions seemed equally affected.

Where two or more wires run between two stations, the effect of these currents upon the working is easily remedied by substituting the second wire for the earth to complete the circuit. This practice was largely adopted on Monday and Tuesday last.

The most striking fact observed was that on each occasion the currents *ceased* when the auroral display *commenced*. I have not noticed this before, probably because the cessation of the one phenomenon and the first appearance of the other have scarcely ever before been so strongly indicated.

W. H. PREECE

AETHERFORCE

SOME ABNORMAL EARTH CURRENTS.

BY

A. B. Grandy

I HAVE recently encountered phenomena in the domain of earth currents which varied somewhat from the ordinary manifestations with which I am familiar, and an account of which may be of interest.

One of the lines of the Postal Telegraph-Cable Co. carrying three wires, traverses a section on the east bank of the Mississippi, between Venice and Alton, Ill., which was inundated during the recent flood. At one point, about 10 miles from St. Louis, two poles were washed out and two of the wires were broken and fell into the river. The third wire pulled out its pins and remained intact, spanning the break in the pole line, and clear of the water. On grounding the two broken wires at the St. Louis office, a current was formed of sufficient strength to work the instruments on both wires. The current was negative in polarity, with an E. M. F. of about 13 volts, as shown on a voltmeter. The current remained steady, with no perceptible fluctuation for several days, until the wires were taken out of the water and restored to their normal condition. During that time the two broken wires were kept open at Alton, beyond the break; the only "live" wire within three miles of the break was the third wire on the same line, the opening of that at Alton did not affect the current on the other two wires in the least; so that there would seem to be no doubt about the current in them being an earth current.

We have another instance of a permanent earth current in one of our city wires. The wire extends about five miles to a point in the southwestern part of the city where it is "grounded" on the water pipes in a manufacturing establishment, several blocks away from any electric railway or line of telegraph wires. On grounding this wire at the main office, a negative current with an E. M. F. of 15 volts shows itself. This current has remained at its present strength for over five years, and fluctuates but little.

The current is amply sufficient to work the wire without the use of any battery.

In many other wires the earth current is found to be appreciable on an ordinary relay, but does not approach the instances cited in strength or permanence.

[June 8, 1892.

THE ELECTRICAL ENGINEER.

EARTH CURRENTS.

BY

W. Thun

ABNORMAL currents of natural electricity were again prevalent on the telegraph wires on Friday, March 17, though comparatively little interference with the regular working was caused by them. They first became active about 4 p. m., acquired a maximum force about 6 p. m., and were gradually subsiding when the writer ceased taking observations at 9.30 p. m. The following are some of the results of the measurements made over the Western Union wires during that time:

EARTH CURRENT OBSERVATIONS, MARCH 17, 1893.

Time of Observation.	Wires grounded at	Distance	Approximate Resistance	Maximum Current Strength	Electromotive Force Developed
		Miles	Ohms	Milamperes	Volts
4.05 p. m.	Elizabeth, N. J.	15	80	35	2.8
4.15 "	Bound Brook, N. J.	34	—	20	—
4.25 "	Philadelphia, Pa.	91	2275	4	9.1
4.32 "	New Haven, Conn.	78	910	4	3.6
4.35 "	Boston, Mass.	244	2825	7	19.7
4.40 "	Albany, N. Y.	150	2850	2.5	7.1
4.42 "	Albany, N. Y.	147	1170	12	14.0
4.44 "	Middletown, Conn.	71	852	8	6.8
4.46 "	Scranton, Pa.	149	840	8	6.7
4.49 "	Buffalo, N. Y.	422	1862	10	18.6
4.50 "	Albany, N. Y.	160	2220	5	11.1
4.54 "	Haverstraw, N. Y.	39	273	14	3.8
5.50 "	Harrisburg, Pa.	197	1379	7	9.6
5.54 "	Pittsburgh, Pa.	401	3145	5	15.7
6.01 "	Paterson, N. J.	19	210	60	12.6
6.25 "	Pittsburgh, Pa.	410	3420	4	13.6
7.10 "	Long Island City.	4	250	3	7.5
8.15 "	Buffalo, N. Y.	422	1800	3	5.4
8.22 to 8.50 p.m.	Scranton, Pa.	149	840	7	5.8
9.10 p. m.	Hackensack, N. J.	15	—	10	—

The disturbance was characterized by none of those violent fluctuations in the intensity and direction of the forces which formed so conspicuous a feature of last year's phenomena; and at no time was the potential difference between any two grounds greater than about twenty volts.

The strength of the earth currents on some wires exceeded that of the regular signalling currents, though generally for brief periods only, while the rise and fall in value were marked with great deliberation, and without displaying the usual tendency to "reversals" of polarity.

THE ELECTRICAL ENGINEER.

March 29, 1893.

ATHERFORCE

VRIL AND THE AURORA

FROM W. S. GILMAN.

One of the most beautiful electrical phenomena imaginable was witnessed on the evening of the 9th January, 1868, in the office of the Atlantic and Pacific telegraph line, Rochester, New York. Wire No. 1 of this line was down between this city and Syracuse. Suddenly it was discovered that neither wire would work. A continuous current of electricity was then observed to be passing over the wires and through the several instruments, and this while the batteries were detached. The current seemed to be of the volume of a medium-sized pipe-stem, and exhibited the several colors of the rainbow. With the key open the current flowed in waves or undulations, and from the surcharged wire it leaped over the insulated portions of the key and passed along the wires beyond. The same phenomenon was observed at Buffalo and at Cleveland. The gas in the office was lighted without difficulty by holding the end of a wire within an inch or two of the gas-burner. The current was intense enough to shock one holding the wires or instruments; indeed, one of the employés of the office had his fingers scorched by the current. With closed keys the current was continuous, as before stated.

This phenomenon has never been witnessed except when cold weather prevails extensively. The broken wire spoken of, which rested on the ground, was the point of communication with the earth.

Here we may notice one thing not generally known. A portion of a speech of Hon. William H. Seward in Rochester, a few years since, was telegraphed to New York and from Boston to Portland by the electrical influences of the aurora borealis, all the batteries on the line being detached. This feat, it is said, has never been repeated.

The following additional information was furnished in answer to inquires by the Institution:

The questions you put with reference to the Rochester electrical phenomena are thus answered:

1. Whether any appearance of the aurora was visible at the time? I learn of none; sky clouded at Rochester, Toronto, and Montreal, and storming.

2. Whether the discharges were continuous or fitful? From B. F. Blackall, manager of the Atlantic and Pacific Telegraph Company, Rochester, I learn as follows: At 4.30 p. m. trouble commenced while he was "transmitting a telegram to New York over the No. 1 wire, which was afterwards located between Fulton and Syracuse, one wire being broken, and the western end hanging across No. 2, rested on the ground. At the same instant I noticed my relay surcharged with an unusual amount of magnetism. Upon opening my key, which we usually give the sixteenth of an inch play, discharges of electricity, averaging as high as 300 pulsations a minute from one platina point to the other, and the nearer I placed these points the more rapid they occurred. * * * * The fluid was passing from west to east through the key. In addition there was a current about the size of a pin flowing from the core of the helices to the soft piece of iron on the armature, which sounded very much like electricity produced by friction on a glass cylinder when passing to a Leyden jar." The phenomenon continued until about 7 p. m. The writer informs me that he has witnessed a half dozen similar but weaker displays during the past 14 years, and always between 4 p. m. and 7 p. m.

From C. W. Dean, manager of the same line, Cleveland, Ohio, I learn as follows: An extraneous current made it impossible to work the wire on January 9th last. It was first noticed at 9 a. m., when the current grew so strong that

ATHERFORCE

The Auroral Currents.

We are asked if the currents produced on the wires during these displays are atmospheric, acting direct from these auroral phenomena, thus irradiating the heavens, and which weave their triumphal coronas up apparently among the planets? Although there are, unquestionably, large masses of electric clouds sailing in the upper regions of the air during the presence of these auroral displays, yet the fact that all, or nearly all, interference from the currents then exhibited can be prevented by simply using two wires instead of the earth and wire, proves that these currents are caused by a disturbance of of the earth's normal electric state. The earth's ordinary electric tension is disturbed, and its currents are, so to speak, scattered by this induced current from the vast masses of electricity in the sky, but are ever seeking, by the violent action peculiar to them, to restore themselves to their normal condition, thus causing temporary electric currents of great power and rapid changes of tension. Thus they enter a wire from one earth connection in this effort at restoration, and are chased back by another from the opposite extreme, exhibiting the violent and changeful currents which mark these magnetic storms. The earth, itself, is a great reservoir of electricity, offering no sensible resistance to the entrance of electrical currents, yet varying in its electric tension or condition at different points. This causes an almost ceaseless action of the earth's currents, and at almost all times they can be felt upon the wires which they use to effect the equalization of their tension. During the auroral displays this action is excessive. At the same time it can scarcely be regarded as incorrect to say that it is the induction of vast volumes of electricity from the upper air which causes these extraordinary currents which, as we have seen, can be utilized and harnessed for human service; and as a line can be worked by any polarity, provided the whole wire is worked with a like polarity, the changing currents do not prevent the line from being operated during the violent contest for the supremacy of the one current or the other.—*Journal of the Telegraph.*

Berlin

Physical Society, December 3, 1886.—Prof. von Helmholtz in the chair.—Dr. König exhibited a von Kries colour-mixing apparatus, the third specimen of the kind hitherto turned out in the factory of Schmidt and Hänsch, and discussed in a searching manner the construction of this instrument. The instrument contained essentially two displaceable slits, the light of which was by a prism decomposed into two spectra falling on each other and producing the mixture of the colours. A second double slit, and a simple fifth slit allowed a comparison of the mixed colours and an admixture at pleasure of white light.—Dr. Weinstein reported on his deductions from observations of the earth's current in the telegraph lines of the German Empire. Among the results already elsewhere published of his calculations (*vide* NATURE, vol. xxxiii. p. 624) it may here be brought out that, apart from its disturbances, the earth's current showed a daily period with eight fluctuations, which, however, did not occur throughout the whole year, nor always in a similar direction. These fluctuations were least in the morning between five and seven o'clock. They were the cause that the statements respecting the daily maxima and minima differed so considerably among the different authors. The earth's current showed an intimate relation to the earth's magnetism, and especially to the declination. The speaker failed, however, to discover a relation in the earth's current to the period of the sun's rotation, although such a relation was asserted for the earth's magnetism. The latter, too, was a point which the speaker doubted, and that because he had been unable to confirm the relation, which was likewise affirmed, between the aurora and the sun's rotation. It was true he obtained an average period of about twenty-five days, but the minima amounted to twelve and the maxima to thirty-seven days, and between such extremes a mean was not allowable. For the earth's current likewise he found minima of twelve days and maxima of thirty-seven days, and this result appeared to him to conflict with the assumption of a connection between the earth's current and the sun's rotation. He conjectured that in the case of the earth's magnetism single values deviating too strongly from one another had been united into a mean. Be it further related that the intensity of the earth-current proved itself to be nearly proportional to the length of the lines. In the discussion following this address, Dr. Brix spoke of the earth plates which had been introduced in the lines used for measurements of the earth-currents, and which had hitherto proved so little disturbing that for the present the introduction of unpolarisable plates was desisted from.

ATHEREOS

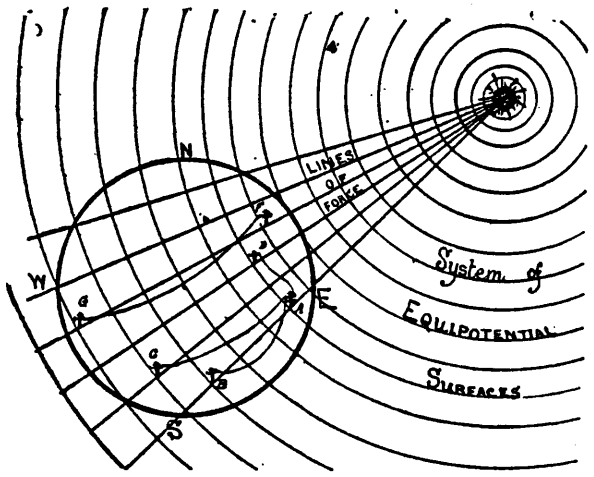
MISCELLANEOUS.

EARTH CURRENTS.[1]

BY WM. FINN.

THE author began by discussing magnetic or electric storms, their causes and effects, and the probable way in which these electrical disturbances, produced by solar convulsions, are transmitted in waves through the ether and imparted to what he termed the "electrical atmosphere" of the earth, inducing electrical waves, or earth currents. During the prevalence of these earth currents, he said, the earth's surface is divided into equipotential planes, between any adjacent two of which a difference of potential always exists. The greatest interruptions are invariably felt along lines of force running across these planes.

The accompanying diagram roughly illustrates the manner in which an electrical disturbance is propagated from the sun to the earth. The disturbing force gives rise to a series of electrical impulses which are transmitted in all directions through space in the form of spherical waves which develop upon the surface of the earth those lines of equal pressure or potential represented in the drawing as circles or portions thereof. The electric force like many other forces diminishes with the distance according to the law of inverse squares, but the value of the force at a given point on any one of the circles is the same as at all other points on the same circle because they are all equally distant from the centre of disturbance. Hence such a circle represents an equipotential surface along which the natural forces are inactive. All other surfaces, however, will necessarily have different values, and therefore an inequality of potential exists which tends to create an E. M. F. in any telegraph wire connecting the various circles. It is



this difference of potential which drives the electricity through the wire.

The straight lines radiating from the sun represent the lines of electric force along which the earth currents are impelled with the greatest velocity, as it were. Telegraph circuits that run along these lines of force, such as A B and F G, are the ones *most* strongly affected. Circuits that cut the equipotential circles at other than a right angle, as A C, are not so seriously troubled, while those wires terminating on any part of an equipotential surface, as A D are absolutely free from interruption.

If we know the direction in which the circuits are entirely destitute of earth currents, we can deduce therefrom the line of maximum force, for that line is always at right angles to the system of equipotential surfaces.

These planes generally run about north and south in this country, and it is on that account, that telegraph lines extending in this direction are found comparatively free from interference during abnormal earth current visitations, while those wires running across the equipotential planes, experience the maximum disturbing effects, which accounts for our easterly and westerly circuits being the greatest sufferers at such times.

The magnitude of the forces developed in the wires evidently bears some relation to the length of the circuit, as might be naturally supposed, and experience shows that the maximum potential difference exists as a rule between the terminal grounds of our longest wires. During the past term of storms for instance, the circuits between New York and Buffalo, which vary from 450 to 482 miles in length, exhibited the highest E. M. F's.; the value of which on several occasions exceeded 600 volts, and on Aug. 12 last, reached the unprecedented magnitude of 708 volts.

Twice or thrice during the recent storm period, there appeared to be a sudden shifting of the equipotential planes to an easterly and westerly direction, which is quite an unusual, as well as remarkable, circumstance, and one quite difficult to properly account for. At the times referred to, the wires north and south, which had previously experienced little or no interruption, became totally unworkable, whereas the easterly and westerly route appeared to be more or less clear of the earth currents. There were times also when a number of wires between the same points would be influenced in such a manner, that while one or two might be found perfectly workable the rest could not be operated at all. These curious anomalies together with other strange inconsistencies that were noted at the time, can only be explained on the supposition that some of the equipotential lines instead of forming portions of spherical surfaces, were more or less distorted by the action of other disturbing influences into highly irregular figures such as the spectrum of one magnet would show in the presence of other magnets. Irregular curves formed in this way and passing through the various points noted—*all being necessarily at the same potential*—would render possible the maintenance of regular communication between such points.

The author then devoted some time to the various theories concerning normal earth currents, and showed diagrams of readings taken upon a portion of the Atlantic cable in 1857 illustrating electrical tidal effects. The effect of local interferences upon the working of telegraph lines was then considered at length, and the paper closed with the statement that, although the phenomena of earth currents are but imperfectly understood, their effects are so universal and important that it requires no great stretch of imagination to conceive the possibility of an extended application of these currents to useful purposes at some future time.

1. Abstract of a paper by read before the Brooklyn Institute of Arts and Science.

AETHERFORCE

(2.) LETTER FROM MR. CHARLES CUTTRISS.

THE COMMERCIAL CABLE COMPANY. MACKAY-BENNETT CABLES.
NEW YORK, July 23, 1892.

PROF. CLEVELAND ABBE.

Dear Sir, — Yours referring to the electrical phenomena of the 15th, 16th and 17th to hand.

I take pleasure in giving you all the data we have on hand, but as you will understand, our receiving apparatus is of the most delicate order and we never permit any strong currents to pass through it. Consequently of the major part of the disturbances we have no record. Further, in order to prevent our business being delayed by extraneous currents, we employ condensers in circuit with our apparatus, and therefore currents of considerable intensity could exist on our cables without our having any record of them unless they varied somewhat rapidly in potential, when of course they would manifest themselves. This will undoubtedly account for our not observing any disturbance during the 15th or 17th, and on the 16th only for a period of about two and one-half hours. The electrical waves attained sufficient strength and changed in potential with sufficient rapidity to record themselves at 12.21 P. M. on the 16th inst. They were quite strong, and in some cases between 12.21 and 12.25 the difference of potential must have exceeded 50 volts. Between 12.25 and 12.28 I judge there were cases of upwards of 50 volts difference of potential from 12.28 to 12.30. I do not think any wave gave a difference of more than 30 volts. From 12.30 to 12.31 one wave possibly gave a difference of 50 to 60 volts. From 12.31 to 12.39 no wave exceeding 15 to 20 volts. From 12.39 to 12.39.45 there were 6 waves of about 35 to 45 volts, but from 12.39.45 to 12.40, there was a wave of such exceptional severity that in order to save our instruments I at once put the cable to earth. This wave undoubtedly must have exceeded 100 volts. From this time until 2.56 P. M. we occasionally found periods when work could be safely resumed, but from 2.56 P. M. we have no further disturbance recorded. I regret my inability to furnish you with more exact data, but you will understand that from the reasons given above we cannot take the risk of damaging our instruments or the cable by attempting to measure these currents, but on the first approach of a severe disturbance we ground the whole apparatus. The differences of potential that I have given are such as I should judge would cause a wave of the character recorded, if it was applied in the form of a battery at the distant end of the cable, but as you will understand it does not necessarily follow that both ends of the cable were of opposite sign, and the current recorded may have been transferred through the dielectric; in this case both ends of the cable would have the same sign, and the disturbance producing it must have been enormously larger than the figures I have quoted.

If at any time I can be of service to you in connection with the[illegible] or other observations, I should be most happy to do all in my power. Yours truly, CHAS. CUTTRIS,

Electrician C. Cable Co.,
Room 116, *Drexel Building, New York.*

To PROFESSOR CLEVELAND ABBE.

ATHERFORCE

Time.	Current Strength.	E. M. F. Developed.
12.40½	133 Milliamperes.	492.1
12.41	68 "	251.6
12.43	20 "	74.0
12.44	15 "	55.5
12.45	19 "	70.3
12.46	14 "	51.8

A wire between New York and Elizabeth, N. J., showed the following variations: —

Time.	Current Strength.
1.51 P. M.	55 Milliamperes.
1.53 "	15 "
1.55 "	80 "
1.55½ "	95 "
1.56 "	25 "
2 "	40 "
2.10 upwards of	150 "

The maximum difference of potential between the distant grounds being about 210 volts.

Other wires of different lengths and extending in various directions showed equally strong and fluctuating forces traversing them, notably in a New York-Philadelphia wire, and in a circuit between Chicago and Omaha, in which pressures of 140 and 390 volts respectively were obtained.

The line of least intensity at any time during the disturbance was apparently north and south, though circuits running in this direction were frequently as useless for practical purposes as those in the direct line of the storm.

The exciting forces quieted down somewhat by 3 P. M., but continued to interrupt the wires (more especially those running east and west) at short intervals during the remainder of the evening.

They were active at irregular intervals and for variable periods all night, and during a portion of the following day.

They have not since been observed on aerial lines, but appear to have subjected the Atlantic Cable Circuits to further inconvenience on Monday and Tuesday, July 18 and 19.

The American Meteorological Journal.

Atmospheric Electricity, Earth Currents, etc.

ATHERFORCE

LECTURE VIII.

ON ELECTRO-MAGNETISM.

Discovery by Oersted—Mutual actions and relative motions of magnets and wires carrying currents of Electricity—Induction of permanent magnetism on steel and temporary magnetism on soft iron—Ritchie's Rotating Magnet—Rotating coil—Electro-magnets of Roberts, Radford and Joule—Ritchie's observations on Electro-magnets—Electro-magnetic Engines: Davenport's, Taylor's, Davidson's, Jacobi's, Talbot's, Wheatstone's, Henley's and Bain's—Galvanometers: Ironmongers' hydrostatic galvanometer—Dr. Locke's Thermoscopic galvanometer—Electro-magnetic telegraphs: Alexander's, Morse's, Davy's, Wheatstone and Cooke's needle telegraph; their improved Electro-magnet telegraph; their printing telegraph—Methods of insulating the wires—Bain's Experiments; his Electro-magnetic printing telegraph; his other applications of Electro-magnetism; his Electro magnetic clocks—The Rev. Mr. Lockey's contact formers—Wheatstone's Electro-magnetic clock.

(573) The disturbance produced in the magnetic needle by the aurora borealis and lightning, had long suggested to philosophers that the agencies of Electricity and magnetism must be connected by some close and intimate relation. For nearly half a century the discovery of this relation was a favourite subject of speculation; and it is curious to compare the various opinions which were maintained by different experimentalists. Magnetic properties were easily communicated to bars of steel, by passing strong electrical shocks through them, but no general law could be traced as governing the polarity thereby imparted. D'Abilard imagined, that he had proved that the electric discharge imparts a northern polarity, to that point of a steel bar at which it enters, and a southern polarity to that at which it makes its exit: and this quite independently of the position of the needle, with respect to the magnetic poles of the earth. Wilke, on the other hand, was equally satisfied that an invariable connexion exists between the negative Electricity, and the northern polarity.

AETHERFORCE

EARTH-CURRENTS AND THE AURORA BOREALIS OF FEBRUARY 4, 1872

IT is unfortunate that more accurate observations of the electrical phenomena accompanying auroral displays cannot be made upon the telegraph wires of this country. The truth is, public business cannot be made to suffer for scientific investigation, and at such moments the disturbance of the wires makes it more than ever imperative that delays should not occur. The whole efforts of the staff are directed to maintain the communications intact, hence the observations made on February 4 are not very numerous, though they are sufficiently interesting to deserve record.

At Portsmouth twenty-six observations were made of the direction and strength of the earth-currents on a wire extending from Portsmouth to London, *viâ* the London and South-Western Railway—a length of 74 miles, giving a resistance of 995 ohms. These were as follows :—

Time.	Direction of	Strength.	Remarks.	Time.	Direction of Current	Strength.	Remarks.
5.54	P	30°	The observations were made upon an ordinary vertical galvanometer, and 40° was equal to about 20 Daniell's cells.	6.41	P	40°	No observations made between 6.41 & 7.35.
6. 8	,,	20		—	—	—	
6.11	,,	10		7.35	—	0	
6.13	,,	30		7.42	N	41	
6.15	,,	25		7.56	,,	68	
6.17	,,	40		8.6	—	0	
6.19	,,	30		8.8	—	0	
6.21	N	15		8.15	N	35	
6.23	,,	24		8.22	P	12	
6.25	P	20		8.28	—	0	No observations made between 8.30 & 9.0 P.M.
6.27	,,	20		8.30	—	0	
6.29	—	0		—	—	—	
6.31	P	8		9 0	—	0	
6.33	,,	13		9.40	—	0	

P means Positive from London to Portsmouth.

The officer who made these observations writes :—"Strong deflections arising from earth currents were observed on all circuits except the local ones. The duration of the currents changed from north to south at intervals of a few minutes, and varied in strength from 1° to 68°. The strength of the current was proportionate to the length of the wire. Thus Chichester circuit (a short one) was affected less than the Guildford, and the latter less than the London circuits. The working was maintained to London with comparative ease by looping two circuits together at each end." The latter method is that usually adopted to overcome the disturbance due to earth currents, but of course it is only applicable in places where there are two wires or more.

Another officer at the Waterloo Station, London, observed the deflections gradually appear on every needle circuit, of which many concentrate at that station. They commenced about 2 P.M., and from that period to 8 P.M. they had all alike been more or less disturbed. It was noticed that the needles moved over gradually, not by a continuous motion, but by jerks, resembling that of the minute hand of a large clock. This has, however, been proved to be due to the friction of the pivots, and not to any pulsations in the currents.

The currents were always most apparent, and first noticeable on the longest lines, and as the lengths of the circuits terminating at Waterloo are very variable, this gradual appearance was very interesting. Lines running south-west and west appear to have been most affected.

All the wires in the Channel Islands were also very much disturbed. In fact Jersey was broken down to England for three hours, owing to the fact of there only being one cable. The section most affected was that between England and Guernsey. It was also noted that the wires in France were very much influenced.

The records from abroad show that, as in previous cases of storms of this character, the effect has been simultaneous all over the globe. The French Atlantic cable was seriously affected; the strength of the current was at one time equal to 90 Daniell cells. It was at times impossible to read even with condensers in circuit. The American lines were also disturbed in the East, West, and North, but not in the South.

It is much to be regretted that simultaneous observations cannot be made in various parts of the globe, detailing, in comprehensible units of measurement, the direction and strength of these currents, as well as the exact time of their appearance and disappearance. We might then arrive at some knowledge of their cause.

Southampton, Feb. 24 W. H. PREECE

MAGNETIC AND SUN SPOT PHENOMENA FOR FEBRUARY, 1870.

(As recorded at the Kew Observatory.)

ON February 1st about 5 p.m. there occurred a very considerable disturbance of the three magnetic elements, which lasted until about 2 o'clock in the early morning of the next day. The tendency of this disturbance was to diminish the declination and the horizontal force, while on the other hand the vertical force was increased during the first half of the disturbance and diminished during the second. The oscillations of the declination were very large. The disturbance was accompanied with an aurora, which was widely observed, and also with earth currents affecting the telegraphic wires. From the appearance of the traces one is inclined to associate the aurora and earth currents with the oscillations of declination rather than with those of the other elements.

On February 11, a little after 6 p.m., another disturbance took place, which continued more or less for thirty hours. As in the previous case the oscillations of the declination were most marked, but these were not so excessive as for the previous disturbance. An aurora was visible at 8 50 p.m. of February 11, and one was said also to have been observed on February 12.

The following is the record of sun-spots derived from the pictures taken :—

February 5	... 4	small groups	2 large ones
,, 6	... 5	,,	1 rather large, 1 very large
,, 8	... 5	,,	2 large, 1 very large
,, 10	... 3	,,	4 large, 1 very large
,, 11	... 4	,,	2 very large
,, 15	... 5	,,	1 large, 2 very large
,, 20	... 7	,,	1 large
,, 21	... 5	,,	1 large
,, 22	... 5	,,	
,, 24	... 4	,,	
,, 25	... 3	,,	
,, 26	... 4	,,	

AETHERFORCE

EARTH CURRENTS AND ELECTRIC TRACTION.

On Friday evening Prof. A. W. Rücker, M.A., D.Sc., Sec. R.S., M.R.I., delivered a lecture at the Royal Institution on "Earth Currents and Electric Traction." Sir William Crookes presided.

Prof. RUCKER first referred to the electrical currents which traversed the earth's surface. In addition to these he had reason to believe that there might be, at great depths within the earth, currents of greater importance, to which the phenomena of terrestrial magnetism were due. Further, we had reason to believe that some currents might flow into the atmosphere, itself a seat of electrical phenomena. It was possible that currents might flow from earth to air, and from air to earth. But apart from all these there were other currents of considerable force which were distributed in the earth from dynamos, with the result that great electrical disturbances had taken place at some of the magnetic observatories; so that in reality, earth currents might be divided into two classes—natural and artificial. Natural currents might be divided into those which existed near the earth's surface, those which might flow at a considerable distance beneath the earth's surface; and those currents which flowed from earth to air, and from air to earth. He first considered the currents which flowed at a considerable distance beneath the earth's surface. At a depth of 10 or 12 miles we should come to a point where magnetised bodies would cease to be magnetic, as the increased temperature would be sufficient to destroy that property. He illustrated this annihilation of magnetic force by means of a piece of basalt, and pointed out that the argument, which would hold good in the case of iron, would also apply to the rocks in which iron or its oxides were found. A very interesting experiment made by Mr. Henry Wilde was referred to, in which an attempt was made to imitate the magnetic condition of the earth. A globe of about 18in. in diameter and containing a spindle around which iron was wound was inclined at a certain angle. There were really two sets of wires through which a current could be passed. The interesting and important thing was this, whether, when a small magnet was placed near this artificial globe, it would behave towards it the same as a magnetic needle would on the surface of the earth. But it was found that what on the artificial globe so formed the ocean parts had to be covered with a thin sheet of iron, and immediately there was obtained the most remarkable agreement between the model so constructed and the earth itself. In the course of further experiments there was thrown on a screen what he called a shell—an oblong piece of metal with a small magnet in the centre. Fine iron filings were indiscriminately scattered within and also outside this shell. The effect was that the enclosed filings immediately assumed magnetic lines, while those at the outside of the rim were still free and retained their original position. Conversely, when the magnet was placed outside the rim, the filings all around it arranged themselves into magnetic lines, while those enclosed remained perfectly free, and, of course, unchanged in position. The magnetic curve lines of both hemispheres of our earth were shown on the screen and described, and the lecturer proceeded to enquire into the existing differences of magnetic matter under the seas and on land. If there was such a thing as an iron shell round the earth, then there might at once arise a suggestion as to the nature of meteoric iron. But on inspecting the great Australian meteorite in the British Museum, he found that this showed no magnetism at all except that due to our earth's induction. The same held with a number of the smaller meteorites he had tested also at South Kensington. He experimented with a large piece of meteoric iron which had been lent to him. On testing this with a sensitive magnetic needle, the same result was apparent, the attractive force being still due to our earth's induction. Terrestrial magnetism was one of the most backward of the sciences. We did not really know why the earth was magnetised. Speaking of artificial currents and their danger to magnetic observatories, and to a less extent to colleges, he said the disturbances caused by these were first noticed in America, where the lines for electric traction were first laid down very roughly, with the result that large earth currents were allowed to disturb the neighbourhood. He showed by means of a diagram the disturbances that were caused by the South London Railway, and another diagram indicated those noticed at Greenwich. The promoters of several electric railways had already agreed not to used earthed returns on their lines. He believed that the insulating of the return wire had introduced additional cost and difficulties in the construction of the railways and tramways in question. In the case of the tramways running in the neighbourhood of Kew, it had been arranged to put the return conductor overhead, and to have two trolleys to collect the current instead of one as formerly. In spite of the ready way in which the promoters of the tramways had met the observatory authorities, the next year or two would be a very anxious time with observatories. Observations had been made at Kew now for something like 40 years, and to remove this observatory from the neighbourhood would be a national disaster. Another point he referred to was the possibility of currents flowing from the air to the earth and from the earth to the air. It had been suggested that there was a great system of electrical distribution due to this phenomenon, and that the aurora was connected with it. Of late the question of the determination as to the heights assumed by the aurora had entered upon another phase, but the actual measurement of these heights was open, as he showed, to grave doubts. In conclusion, he alluded to the attempts which were about to be made to add to our magnetic knowledge in the southern hemisphere by the expeditions of England and Germany, both of which would work together, though they would take different routes.

AETHERFORCE

XIII

EARTH-CURRENTS

13.1. Introduction. Variable electrical currents in the earth's crust were first observed when telegraphy along extended lines was introduced. In the circuit formed by the line, grounded at the ends, and the earth, irregular currents of much higher intensity than the artificial currents used for telegraphic communication appeared occasionally and obliterated the signals. Such 'earth-current storms' occur at the same time as magnetic storms and aurorae, and therefore share several characteristics such as world-wide appearance, relations to sunspots, 27-day recurrence tendency, higher frequency at the equinoxes, and so on. This similarity points to a close physical relationship between the two phenomena, and is the main reason why these 'telluric currents' are discussed here along with geomagnetism.

Burbank [2], in a bibliography of the early literature, ascribes to Barlow [1] the first observations 'On the spontaneous electric currents observed in the wires of the electric telegraph', made in 1847 on the English telegraph lines. In the same bibliography we find the characteristic title of a German book by Clement [3] on 'The great northern light in the night before the 29th of August, 1859, and the confusion of the telegraphy in North America and Europe'; aurora was seen in latitudes as low as 14° (north) on the Atlantic, and on some telegraphic lines in France the greatest effects observed were equivalent to 800 volts for a distance of 600 km. Natural potential differences of several hundred volts also occurred in Norwegian cables during the great magnetic storm of 1938 April 16 (p. 329).

Systematic observations of earth-currents are best made by two more or less independent steps. (*a*) Continuous records are made of the natural potential differences between the ends of two straight insulated wires, from 1 to 10 km. long, orientated north-south and east-west. Each wire ends in two electrodes buried in the ground, and the potential differences between the electrodes are recorded by suitable voltmeters (potentiometers). In this way the measuring system does not carry a current, and interferes as little as possible with the natural conditions. (*b*) In addition, the distribution of the conductivity of the soil is determined by special surveys. The earth's resistivity below the uppermost layers depends only on geological conditions, and therefore varies only slowly with time; but changing meteorological conditions, especially

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been available for such measurements, and since their construction is not suitable for exact tests, no satisfactory results have been obtained; that is to say, the measurements do not give conclusive evidence of a constant part in the earth-currents, which is greater than the contact-potentials of the electrodes on long lines, that is, greater than about 0·1 volt per 100 km., or 1 millivolt/km. In the discussion of earth-currents, therefore, we have so far no counterpart to the planetary permanent magnetic field of the earth; our discussion is confined to the variations occurring within such time limits as to exclude changes

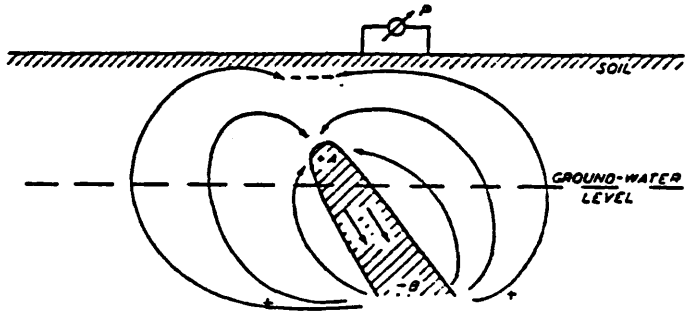

FIG. 5. Illustrating electric earth-currents due to spontaneous polarization

of the contact-potentials. These variations are the regular daily changes, and the irregular changes during magnetic and earth-current storms.

The first indication of a real change in earth-currents, with a period longer than one day, is afforded by Rooney's [46] discovery that the daily mean of the potential gradient for a very disturbed day differs from that for a markedly calm day by about 0·1 millivolt/km. at Tucson (Arizona); this amounts to a few per cent. of the amplitude of the daily variation; at Huancayo an effect of similar relative magnitude is found. The additional average current on disturbed days is directed toward the north-east at Tucson, and to the south-east at Huancayo; these directions may be modified by local geological features.

13.12. Spontaneous polarization. An exception to the statement in § 11, that constant earth currents or potential differences cannot be observed, is found in the small-scale 'self-potentials' measured over certain ores. Consider (Fig. 5) a copper sulphide ore under an overburden of 20 feet. Owing to the moisture of the soil the upper portion of the vein is oxidized. Thereby an electrochemical potential difference of half a volt or more arises between the upper and lower portions, and currents flow downward in the well-conducting vein, and upward in

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the poorly conducting surrounding soil, as in a battery. The current-lines near the surface converge to a 'negative centre' above the ore, and the equipotential lines surround this centre. These potential differences can be found by means of non-polarizable electrodes, much in the same way as in the case of an artificial current-supply (§ 5). The method is restricted to sulphide ore-bodies of a pyritic character, and fails even there if an impervious clay overburden prevents percolation and, thereby, active oxidation. But in many circumstances spontaneous polarization is a good indicator; as early as 1830 Fox [47] placed large copper plates as electrodes against the rock inside Cornish mines, measured the natural current with a galvanometer, and located large deposits.

Much smaller in individual size and intensity, though perhaps a more common phenomenon, are the 'turbulent currents' measured by Hunkel [28] with non-polarizing electrodes; they appear as irregularly distributed positive and negative poles of a few millivolts, at distances of the order of a foot. They seem to be connected with small inequalities in the chemical disintegration of the soil, causing local differences in the 'acidity' of the soil solutions. Near faults, the disintegration extends deeper, and more intense poles can be expected.

13.13. The problem of vertical earth-currents. Between two earth-electrodes placed in the soil at different altitudes on a hill-side, there is generally an average potential difference of the order of 100 millivolts per km. length of the line, with a current flowing in the connecting wire toward the upper station. This current seems to be more constant and relatively less variable, the steeper the line; its variations do not change in accordance with the terrestrial-magnetic variations, as do the earth-current variations in horizontal lines [2, 48–50]. But observations on a line extending up the side of Vesuvius revealed that the current, which flows upward during volcanically quiet times, is reversed during times of volcanic activity. At the Ben Nevis Observatory in Scotland a strong current which flowed upward when the summit was clear, was reversed when fog or clouds enveloped the summit.

Gish [49] is sceptical as to these measurements. If the currents measured in the wires do actually flow in the soil from all sides of the mountain top, the circuit must be closed somehow. If it is assumed that the gradient has the same upward direction throughout the mountain, then the current should be closed through the air; a large current would go into the air on the summit. This, however, is exactly the opposite direction of the air-earth current observed in atmospheric electricity.

ÆTHERFORCE

In fine weather the downward potential gradient in the air is about 1 volt/cm., which, with an average resistivity in the open air of 6×10^{15} ohm cm., results in a current-density 2×10^{-16} amp./cm.^{2} flowing from the air *into* the ground. The magnitude of the apparent 'uphill' earth-currents, with a voltage of, say, 0·2 volt per km. height difference, or 2×10^{-6} volt/cm., flowing in earth of resistivity 10^5 ohm cm., would be 2×10^{-11} amp./cm.^{2}, that is, 100,000 times more intense than the actually observed air-earth current.

This leaves only two alternatives: either we must assume that the 'uphill' currents form closed circuits with currents flowing downward in the interior of the mountain, or that they only represent systematic electrode effects due, for instance, to a variation of acidity (hydrogen-ion content) of the soil with height, depending on height-differences in erosion or weathering. In the latter case, the mountain resembles a battery in which a current flows only when the circuit is closed by the electrodes and the wire between. No final decision has been reached as to such possible electrochemical or thermo-electrical processes.

Lemström [10], as long as fifty years ago, put his 'point-apparatus' on the tops of the Finnish mountains; it consisted of barbed wire (fastened on insulators) covering several hundred square metres of the top, and was connected, through a galvanometer, with an earthed plate in the valley. The numerous point-discharges—at night sometimes visible as Saint Elmo's fire—set up a downward current, which is readily explained as a consequence of the normal atmospheric-electric vertical current. Similar but much weaker currents are observed in the wires leading to ordinary aerials (antenna-currents).

13.14. The general character and magnitude of earth-current variations. At a number of places where earth-currents have been observed, among them Watheroo, Huancayo, Ebro, Paris (Parc St. Maur), and Batavia, the direction of the resultant current-flow is practically restricted to a single azimuth or its reverse. Although this peculiarity is absent at a few stations (for instance, at Tucson, Arizona, where the direction of the resultant flow may vary considerably), it is striking that it should be found at such widely spread localities, especially where the resistivity is found to be so laterally uniform as near Watheroo and Huancayo. In 12 earth-current systems, each about 200 km. long, operated on the cables and wire-lines of the Bell System along the eastern coast of North America from Maine to Cuba [56], this pronounced constancy of direction (there, towards the north-west or south-east) is found to prevail along the eastern part, possibly even

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into Cuba; but there are three stations (in Maine, in Illinois, and in the lower Mississippi valley) where the resultant current-flows are not strictly alined, but vary in direction.

Another general feature is the close relation between the earth-resistivity of the locality and the magnitude of the earth-current variations. A remarkable example was observed at Huancayo; the east component was in the earlier years recorded on two lines, and the potential gradient was found to be nearly twice as large on the line laid where the resistivity was locally about three times as high as is generally found in the region. Since the current-density equals the ratio of the potential gradient to the resistivity, this would suggest that the magnitude of the current-density varies less, from place to place, than that of the potential gradient. In Watheroo the potential gradient on quiet days, averaged for a certain hour, is of the order 1 millivolt/km. $= 10^{-5}$ volt/cm. which, with ρ approximately equal to 1,000 ohm cm. up to 300 m. depth, indicates a current-density of roughly 10^{-11} amp./cm.^{2} At Huancayo, the corresponding value is about 3×10^{-8} (volt/cm.)/10^4 ohm cm. $= 3 \times 10^{-12}$ amp./cm.^{2} During magnetic storms instantaneous values of the current-density may be 10 or even 100 times as high.

13.15. Earth-current storms. The simultaneous occurrence of magnetic and earth-current disturbances is the best established fact about earth-currents. Statistical discussions of the frequency of earth-current storms therefore indicate the same features as are found for magnetic storms, namely, a variation in parallel with the 11-year sunspot cycle, a higher frequency at the equinoxes, frequency of sudden commencements after quiet intervals, and a 27-day recurrence [56] tendency.

As to quantitative relations between the two vectors, the earth-current density and the disturbance of the magnetic force, the evidence is much less conclusive. Van Bemmelen [57] compared simultaneous oscillations, having periods between 1 and 20 minutes of time, in the east earth-current component E and the north magnetic component X. He found that the oscillations have approximately opposite phases—though the highest current towards the east occurs somewhat earlier than the smallest north magnetic force—and that the ratio of the amplitudes of E and X decreases when the duration (or period) of the oscillation increases; but the ratio decreases much less rapidly than the reciprocal of the duration. However, even these results cannot be regarded as significant, because the oscillations in the north earth-

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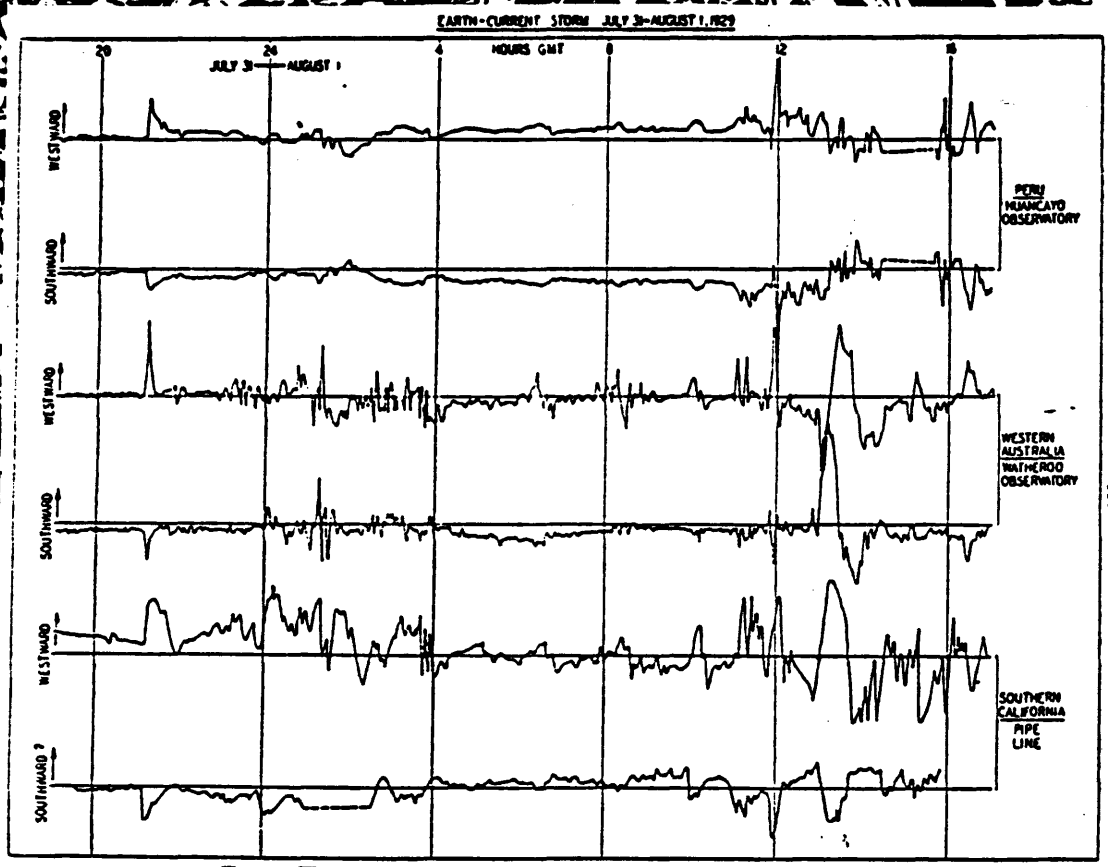

FIG. 6. Three sets of records of an earth-current storm. (After Gish)

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current component N showed much closer relation to those in E than to those in the magnetic east component Y; the 'single-azimuth' character of the earth-current, described in § 14, blurs the relationship with the variations of the horizontal magnetic components which, generally, change much more in direction (9.17 and 9.18).

Nevertheless, it seems to be established that fluctuations of short period, or high frequency, are comparatively more pronounced in earth-current records (Fig. 6) than in magnetic records.

Bosler [58], from the Parc St. Maur (Paris) curves, found a parallelism between X and E, and also between Y and N; an observer looking in the direction of the earth-current would describe this relation as a deflexion of the magnetic force towards the left. Bock and Moench [59] found similarities between the northward earth-current and the variations of declination.

At stations in low latitudes the oscillatory disturbances of short periods (from a few minutes up to an hour) are of about the same order of magnitude as the normal range of the daily variation (expressed in hourly means); only during exceptional storms do they become as much as twenty or thirty times as great. At the polar station of Fairbanks, Alaska [60], the short-period disturbances extending over half an hour or less had amplitudes exceeding the normal daily variations in ratios 50 to 150. Also the absolute resultants were sometimes as high as 1,000 millivolt/km.; this might be partly due to the supposedly high resistivity of the frozen soil. The oscillatory disturbances were practically absent during the hours of daylight. During the night their intensity varied from hour to hour in good correlation with the aurora.

13.16. Daily variations. The tabulated hourly values for the earth-current components are combined in the same way as magnetic observations, in order to obtain the average daily variations, expressed as deviations from the daily mean which, as being without physical significance (§ 11), is not considered. They share the following features with the magnetic daily variations. The variations are more rapid during the daylight hours than at night; their range is higher in summer than in winter. This is most convincingly demonstrated by the Watheroo results [38], because the resistivity at Watheroo has no marked seasonal variation, and also by the Tucson results (Fig. 7). The main variation is in the north components. Observations in the northern and southern hemispheres point to a phase-change near the equator; at midday the main currents flow towards the equator from both sides.

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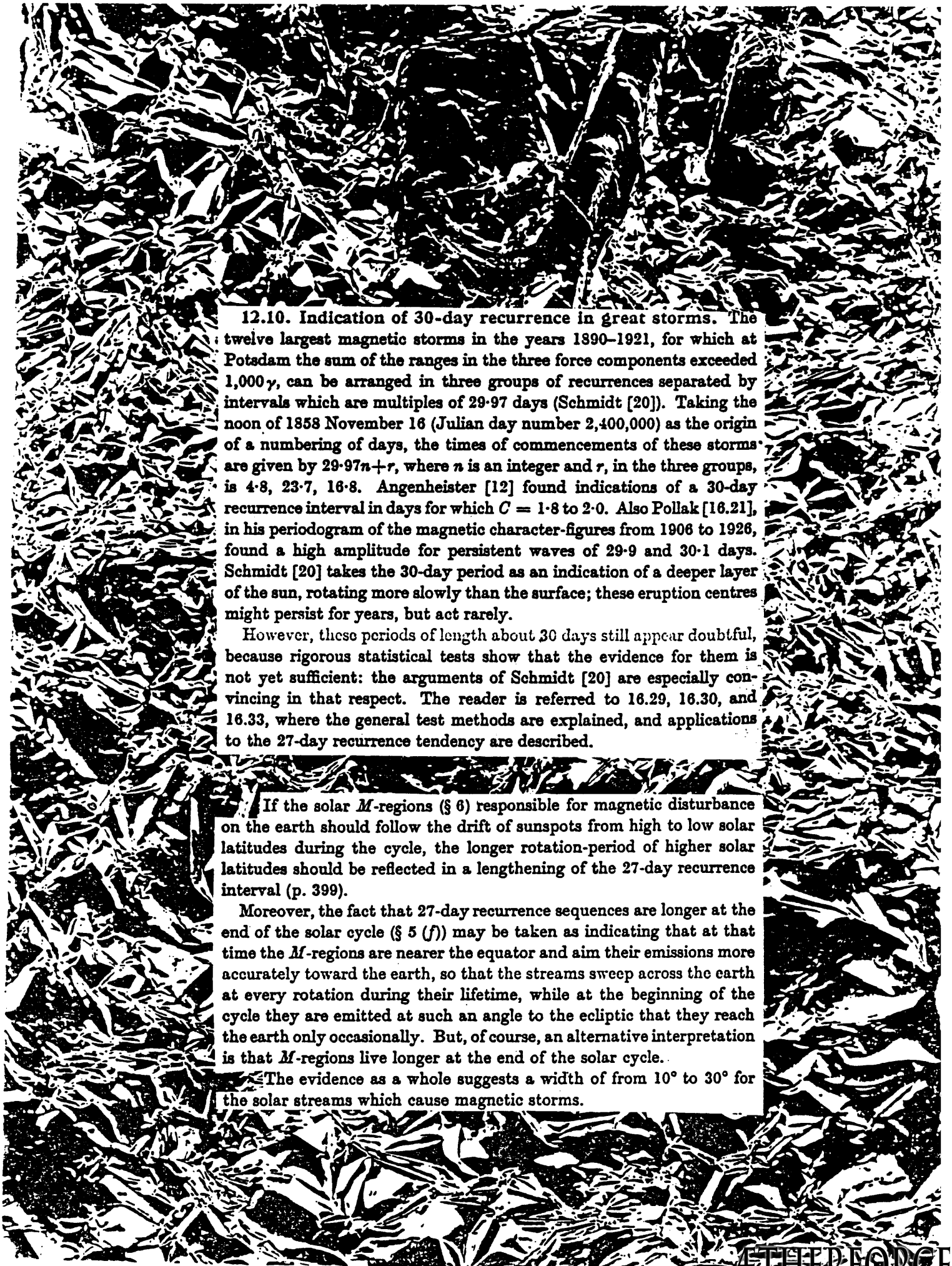

12.10. Indication of 30-day recurrence in great storms. The twelve largest magnetic storms in the years 1890–1921, for which at Potsdam the sum of the ranges in the three force components exceeded 1,000 γ, can be arranged in three groups of recurrences separated by intervals which are multiples of 29·97 days (Schmidt [20]). Taking the noon of 1858 November 16 (Julian day number 2,400,000) as the origin of a numbering of days, the times of commencements of these storms are given by $29{\cdot}97n+r$, where n is an integer and r, in the three groups, is 4·8, 23·7, 16·8. Angenheister [12] found indications of a 30-day recurrence interval in days for which $C = 1{\cdot}8$ to $2{\cdot}0$. Also Pollak [16.21], in his periodogram of the magnetic character-figures from 1906 to 1926, found a high amplitude for persistent waves of 29·9 and 30·1 days. Schmidt [20] takes the 30-day period as an indication of a deeper layer of the sun, rotating more slowly than the surface; these eruption centres might persist for years, but act rarely.

However, these periods of length about 30 days still appear doubtful, because rigorous statistical tests show that the evidence for them is not yet sufficient: the arguments of Schmidt [20] are especially convincing in that respect. The reader is referred to 16.29, 16.30, and 16.33, where the general test methods are explained, and applications to the 27-day recurrence tendency are described.

If the solar M-regions (§ 6) responsible for magnetic disturbance on the earth should follow the drift of sunspots from high to low solar latitudes during the cycle, the longer rotation-period of higher solar latitudes should be reflected in a lengthening of the 27-day recurrence interval (p. 399).

Moreover, the fact that 27-day recurrence sequences are longer at the end of the solar cycle (§ 5 (f)) may be taken as indicating that at that time the M-regions are nearer the equator and aim their emissions more accurately toward the earth, so that the streams sweep across the earth at every rotation during their lifetime, while at the beginning of the cycle they are emitted at such an angle to the ecliptic that they reach the earth only occasionally. But, of course, an alternative interpretation is that M-regions live longer at the end of the solar cycle.

The evidence as a whole suggests a width of from 10° to 30° for the solar streams which cause magnetic storms.

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INTERACTIONS OF TELLURIC CURRENTS WITH MAN-MADE SYSTEMS

The natural telluric current environment can significantly affect man-made systems. Conversely, human technology can "pollute" the natural telluric current environment. The mechanisms by which these interactions occur, as well as their modeling, are far from being understood satisfactorily and comprehensively. Geophysicists have often viewed such interactions as an unwanted, unnatural nuisance. Engineers have almost always been concerned with thresholds of system reliability and with a system's capability to react positively to any sudden change in the natural environment, always on a strict basis of yield/cost ratio. Moreover, technological improvements have been progressively introduced within systems to ensure a higher and higher reliability (e.g., Axe, 1968; Anderson, 1979), so that it becomes difficult to compare effects observed on different systems in different years.

Seldomly have man-made systems been viewed as scientific instruments that are useful for studying the natural environment. Often a man-made system can be considered part of the natural environment itself. Geophysicists can then imagine such large man-made tools as similar to specifically designed measuring instruments that, unlike laboratory instruments that are normally presumed to negligibly affect the system, actually interfere with the natural phenomena, often quite seriously. Such huge and expensive man-made systems can allow, in principle, some complex experiments and measurements, which otherwise could not be carried out. For this reason this topic has particular scientific value, much beyond a matter of scientific curiosity or of a more or less minor nuisance affecting the operation of huge engineering systems.

The literature on the subject tends to be rather sparse. However, five principal areas of interest can be considered. These are discussed below; some of this material has been previously reviewed elsewhere (Axe, 1968; Lanzerotti, 1979a, 1979b, 1979c, 1983; Paulikas and Lanzerotti, 1982).

Communication Cables

Historically, this is the best investigated and documented effect of telluric currents on technological systems. In fact, after the lightning rod, the telegraph was essentially the earliest of man-made electromagnetic devices in use. Subsequently, telegraph lines have been progressively supplanted by telephone lines, and submarine cables have supplanted the former radio links between the telephone networks of different continents (e.g., Blackwell, 1928; Bown, 1930, 1937; Schelleng, 1930). Even with the advent of communication satellites, cable systems are still of major economic importance for long-distance communications.

The first detection of effects on a telegraph wire dates back to the years 1847-1852. The first observations appear to be from England by Barlow (1849). As stated by Prescott (1866):

> M. Matteucci had the opportunity of observing this magnetic influence under a new and remarkable form. He saw, during the appearance of the aurora borealis of November 17, 1848, the soft iron armatures employed in the electric telegraph between Florence and Pisa remain attached to their electromagnetics, as if the latter were powerfully magnetized, without, however, the apparatus being in action, and without the currents in the battery being set in action. This singular effect ceases with the aurora, and the telegraphs, as well as the batteries, could operate anew, without having suffered any alteration. Mr. Highton also observed in England a very decided

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action of the aurora borealis, November 17, 1848. The magnetized needle was always driven toward the same side, even with much force. But it is in our own country that the action of the aurora upon the telegraph-wires has been the most remarkable. . . . In September, 1851, . . . there was remarkable aurora, which took complete possession of all the telegraph lines in New England and prevented any business from being transacted during its continuance.

The days between August 28 and September 2, 1859, were also quite remarkable, not only for some wonderful auroral displays (Clement, 1860; Hansteen, 1860; Prescott, 1860, 1866). Clement's (1860) book had a self-explanatory title: *The Great Northern Light on the Night before 29 August 1859 and the Confusion of the Telegraph in North America and Europe*. According to Chapman and Bartels (1940), this aurora was seen in the Atlantic at a latitude as low as 14° N, while in France 800 V were induced on a wire over a distance of 600 km. From Prescott (1866):

We have, however, the second yet more wonderful effects of the aurora upon the wires; namely, *the use of auroral current for transmitting and receiving telegraphic dispatches*. This almost incredible feat was accomplished . . . on the wires of the American Telegraph Company between Boston and Portland, upon the wires of the Old Colony and Fall River Railroad Company between South Braintree and Fall River, and upon other lines in various parts of the country. . . . Such was the state of the line on the September 2nd, 1859, when for more than one hour they held communication over the wires with the aid of celestial batteries alone.

Other studies of historical interest on telluric currents in communication cables are mentioned in the Appendix.

In 1910 work was begun in Norway by Carl Störmer of measuring the height of polar aurorae (Störmer, 1955). Störmer used photographs taken simultaneously from two sites separated by a few tens of kilometers. He was able to send a message of alert to his co-workers about an imminent night of photographic work whenever he measured disturbances in the local telegraph wires.

A geomagnetic storm in Sweden in May 1921 (Germaine, 1942; Sanders, 1961) produced voltages of 6.3 to 20 V/km (i.e., 1 kV or more over 100 to 200 km, with 2.5 A, while the threshold for serious troubles was 15 mA). A large magnetic storm on April 16, 1938, produced potentials of several hundred volts over local wires in Norway (Chapman and Bartels, 1940).

On March 24, 1940 (Germaine, 1942; Harang, 1951; Brooks, 1959; Sanders, 1961), a geomagnetic storm damaged the Norwegian wirelines ($\lesssim$50-60 V/km, -600 V, >4 A), while in the United States, more than 500 V were estimated to have occurred along some lines. Reports from two sites near Tromso, Norway, stated

. . . Sparks and permanent arcs were formed in the coupling racks and watch had to be kept during the night to prevent fire breaking out. . . . One line was connected to earth through a 2 mm thick copper wire, which at once got red hot, corresponding to a current more than 10 amps (Harang, 1951).

In the second half of the nineteenth century, Earth currents in submarine cables were rather extensively investigated. Saunders (1880, 1881) and Graves (1873) reported some of their work, which included a cable between Suez and Aden and a cable between Valentia and Newfoundland. Wollaston (1881) concluded that his current measurements on a submarine cable across the English Channel resulted from tidal currents and related an 1851 conversation with Faraday on the matter. The latter was quoted as quite enthused about this confirmation of his earlier predictions.

Axe (1968) listed several geomagnetic storm-induced effects on submarine cables occurring in 1957-1967 (total voltage drops range from 50 V to 2700 V for the different occurrences). The largest voltage drop (Figure 16.9) occurred across a transatlantic cable (equivalent to 0.75 V/km) at the time of the huge storm on February 11, 1958, which produced a well-known spectacular auroral display down to low latitudes (Brooks, 1959; Winckler *et al.*, 1959; Sanders, 1961; Akasofu *et al.*, 1966). It is noteworthy that "the cable to Hawaii which originates about 140 miles north of San Francisco exhibited no major voltage swings" (Winckler *et al.*, 1959).

A major geomagnetic event on August 4, 1972, caused the outage of a continental cable in the midwestern United States. The outage has been investigated (Anderson *et al.*, 1974; Anderson, 1979) by modeling the tel-

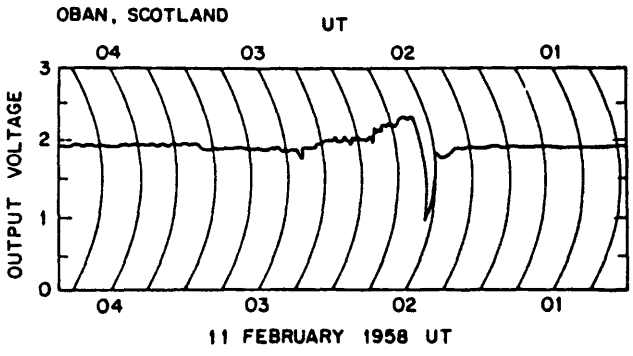

FIGURE 16.9 Output voltage of the power-feed equipment at the Oban, Scotland, end of the Oban-Clareville, Newfoundland, cable. The voltage variation in North America was somewhat larger, leading to a total variation of about 2700 V across the cable. From Axe (1968).

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luric currents in terms of a compressed magnetosphere with magnetopause and magnetosphere currents electromagnetically inducing over a three-layer conducting Earth.

Summarizing, shutdowns in both land and sea cables, as well as fires, have been caused by telluric currents induced by geomagnetic storms, and suitable precautions have to be taken (Root, 1979) in order to attempt to avoid them.

A singular example of man-made telluric current "pollution" occurred when a high-altitude nuclear bomb test produced perturbations in the Earth's radiation belts and geomagnetic field. As recounted in Axe (1968):

> The disturbance was just detectable on the power-feeding voltage and current recorder charts on the Australia-New Zealand, United Kingdom-Sweden and Bournemouth-Jersey systems. On a circuit originally set up on the Donaghadee-Port Kail No. 3 cable for the measurement of voltage due to water flow, the disturbance was clearly recorded.

The data at the time of the event are shown in Figure 16.10 (Axe, 1968).

All the effects considered above refer to electromagnetic induction from ionospheric and magnetospheric variations. However, there are also effects on submarine communication cables related to water flows (tidal and otherwise). The problem has been extensively reviewed by Meloni *et al.* (1983); see later section. Less dramatic, although relevant, man-induced telluric current perturbations on land cables should be expected in heavily industrialized or populated areas (e.g., Kovalevskiy *et al.*, 1961).

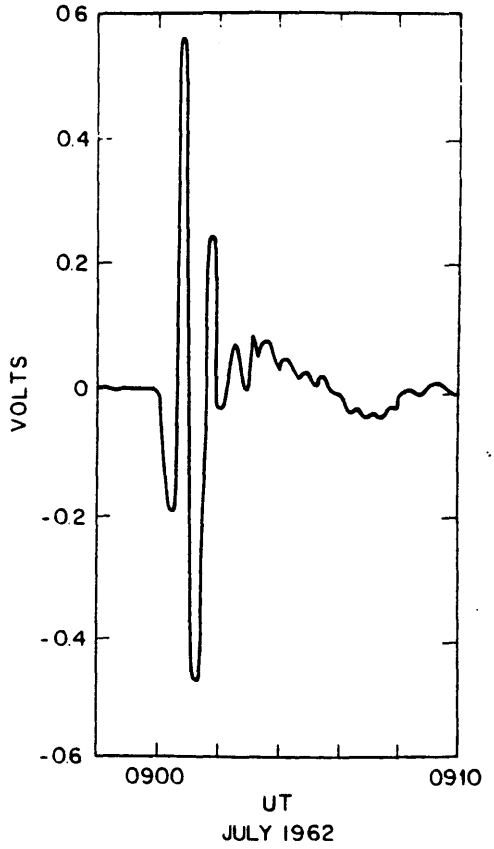

FIGURE 16.10 Effect of the Starfish explosion measured on the center-conductor voltage of the Donaghadee-Kail (Irish Sea) number 3 cable. From Axe (1968).

Powerlines

The historical record of powerlines being greatly distributed or completely disrupted by geomagnetic storms appears somewhat less detailed than that for communications cables. One interruption of service occurred on March 24, 1940, in New England, New York, eastern Pennsylvania, Minnesota, Quebec, and Ontario (Davidson, 1940; Brooks, 1959). As well, during the great geomagnetic storm of February 11, 1958, the Toronto area suffered from a blackout produced by a geomagnetic storm. Currents up to about 100 A were induced in some northern latitude transformers during the great storm of August 4, 1972 (McKinnon, 1972). Induced currents on power systems in the auroral zone have been discussed by Aspnes *et al.* (1981) and Akasofu and Aspnes (1982; see Figure 16.11). Some of the most detailed investigations aimed at establishing engineering relations for power systems have been carried out by

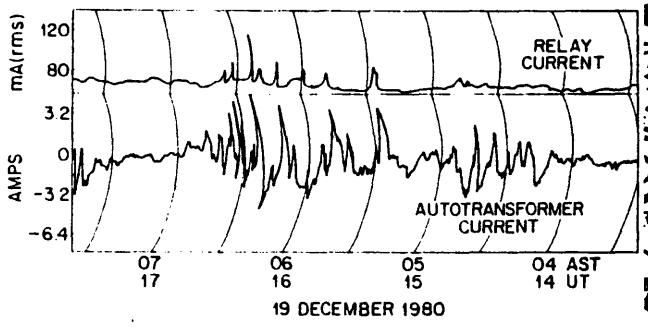

FIGURE 16.11 Simultaneous recordings of geomagnetic induction effects observed as current surges in a positive relay system and an auto transformer in a power substation near Fairbanks, Alaska, on December 19, 1980 (from Akasofu and Aspnes, 1982).

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Albertson and Van Baelen (1970), Albertson *et al.* (1970, 1973, 1974), ACRES (1975) (see also references therein), Boerner *et al.* (1983), and Pirjola (1983).

The geomagnetic currents induced in a power system can produce problems of several different types (Albertson *et al.*, 1973, 1974; review by Williams, 1979). First, the arbitrary differential relay operation in power distribution systems during geomagnetic storms can produce a judgmental problem; system operators are unsure of whether the malfunctioning relay indication is an induced-current effect in a transformer or a real transformer malfunction. Second, the currents actually induced in the winding of a power transformer can result in half-cycle saturation of the transformer core. This saturation can produce fluctuations in the transformer operation itself. This local heating can greatly shorten the lifetime of a transformer.

Summarizing, the effects of induced telluric currents on power systems produce outages as well as damages to expensive transformers. Gorely and Uvarov (1981) estimated that in the Norilsk region (Siberia) up to tens of amperes can be expected on powerlines of 100 to 150 km length. Since 500-kV transformers capable of withstanding even 3 to 4 A without saturating appear to cause problems for manufacturing (Sebesta, 1979), a way of avoiding such serious damage is to use powerlines of limited total length (e.g., Akasofu and Merritt, 1979, suggest no more than 500 km for Alaska). Pirjola (1983), from measurements made at four locations in Finland, concluded that currents of the order of 100 A lasting about 1 h should damage transformers.

Pipelines

Varley (1873) reported that large Earth currents on a short length of telegraph cable in London appear to have been related to currents flowing on large, nearby gas pipelines. Studies of induced telluric currents on pipelines took renewed importance when the long, Trans-Alaskan pipeline (1280 km long) was built. The effects of telluric currents appear to be of most importance in affecting electronic equipment related to operational monitoring and corrosion control rather than in producing specific serious corrosion problems.

Viewing a pipeline as a man-made part of the natural environment, it is noteworthy to mention the 30-A current reported by Peabody (1979) to cross the Panama Isthmus, from ocean to ocean, a current that also changes direction. Such specific currents can produce corrosion failures at some ocean terminals of the pipelines, even before the pipeline is in operation. Such problems can be avoided most simply by suitable separate ground connections (Peabody, 1979).

The Alaskan pipeline has been the subject of careful investigations, principally because of its location across the auroral zone (Hessler, 1974). Campbell (1978, 1979, 1980) and Campbell and Zimmerman (1980) provided a comprehensive account of the problem and concluded that the current I expected to flow within the pipeline is related to the geomagnetic index A_p by the linear relationship $I = 5.0\ A_p - 0.7$. Based on the statistics of occurrence of the A_p index (larger for greater geomagnetic activity), at least once a year about 600 A should be observed, 800 A should be observed at least once every 2 years, and 1200 A should be observed at least once every 5 years. The dimensions of the Alaskan pipeline (diameter of ~ 1.22 m, a mean wall thickness of ~ 1.30 cm, a resistance per unit length of $\sim 2.81 \times 10^{-6}\ \Omega$/m, and an end-to-end total resistance of 3.6 Ω; Campbell, 1979) suggest that it is a large man-made conductor that is capable of significantly affecting the local natural regime of telluric currents.

Railways

Pollution by artificially produced telluric currents associated with railway operations have been investigated from several viewpoints. Burbank (1905) reported the effects in 1890 of the South London Electric Railway on the Earth current records being made at Greenwich. The nuisance for geomagnetic observations of telluric currents associated with return currents from dc electrified railways has perhaps been the most widely investigated effect (La Cour and Hoge, 1937; Rössiger, 1942; Yanagihara and Oshima, 1953; Mikerina, 1962; Yanagihara and Yokouchi, 1965; Yanagihara, 1977). The spatial extent within the ground of telluric currents from railway operations has been investigated by Kovalevskiy *et al.* (1961) in the southern Urals. They detected telluric current pulses with periods between a few seconds and 20 minutes and amplitudes of about 0.5 to 3 V/km. They found the effects to drop off rapidly within 10 to 15 km from the railway, although still being dominant over natural telluric currents at 30 km, and still detectable at 60 km (where the measurements stopped). Meunier (1969), following a previous investigation by Dupouy (1950), detected telluric current effects related to a specific operation (lowering and raising the pantograph) of the Paris-Toulouse railway at 115 km distance from the railroad. This effect, in fact, can sometimes be detected on the magnetograms from the Chambon-la-Forêt observatory. An example of the effect is shown in Figure 16.12. Jones and Kelly (1966) detected Earth currents in Montreal, clearly correlated with a dc powered railway some 20 km distant.

F. Molina (private communication, Osservatorio

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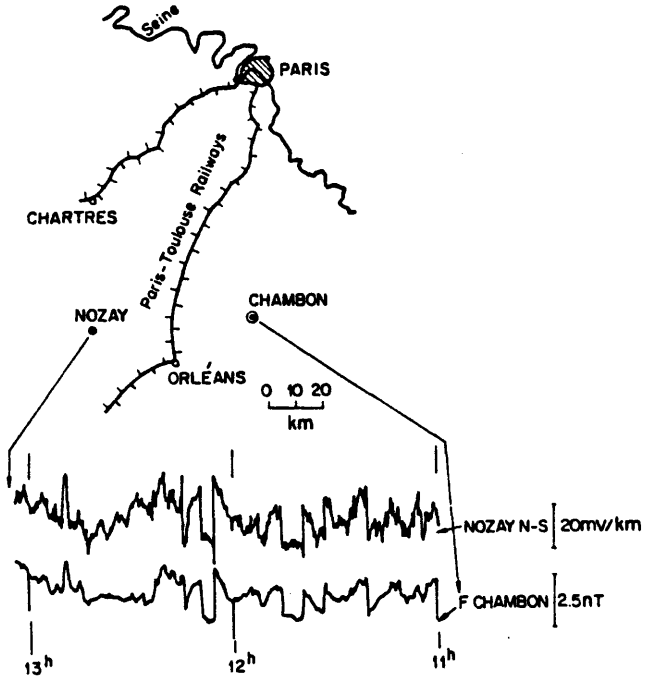

FIGURE 16.12 Artificial Earth currents (north-south direction) measured (Fournier and Rossignol, 1974) at Nozay (France) and concurrent fluctuations in the total magnetic field measured at Chambon-la-Forêt, on opposite sides of the Paris-Toulouse electrified railway line.

Geofisico Monte Parzio, Italy), in close examination of standard magnetogram records from the observatory at L'Aquila, has found a difference in the width of the trace depending on whether the Italian railways are on strike or not. In the former case, the Z-component trace is about a factor of 2 less thick than during normal operations. The noise introduced appears to be about 0.5 nT. The closest railway is about 30 km away.

A most impressive telluric current effect (Fraser-Smith and Coates, 1978; Fraser-Smith, 1981) in the San Francisco Bay area has been produced by BART (the San Francisco Bay Area Rapid Transit system). ULF waves (frequency less than 5 Hz) are observed, having energy at a frequency predominantly below about 0.3 Hz. Their amplitudes are at least ten times greater than the natural background environment, i.e., they are comparable with the levels reached during great geomagnetic storms. The effect originated by BART appears to occur over an area of about 100 km^2.

A similar effect has been detected by Lowes (1982) in Newcastle upon Tyne (U.K.), produced by the dc rapid transit underground railway system. F. J. Lowes (University of Newcastle upon Tyne, private communication, 1985) also noted that when the system starts up in the morning he can follow individual train movements over about 12 km of track before there is too much superimposition of the signals.

Corrosion

Corrosion in buried metal structures (in addition to pipelines) is significantly enhanced by the occurrence of telluric currents, presumably via electrolytic processes. This is a well-known phenomenon to people routinely working on repairs of telephone cables or of pipes (for water or otherwise). Severe damage comes mainly from man-made telluric currents when the conductors are buried close to dc electrified railways or tramways. A simple insulating coating, provided that it has no holes, appears to be the best protection. The problem is discussed to some extent by Peabody (1979). A much older reference (given by Kovalevskiy *et al.*, 1961) is Tsikerman (1960). The problem can exist also for buried powerlines that have, unlike aerial power lines, some relevant problems of heat flow (Salvage, 1975).

APPLICATIONS OF TELLURIC CURRENT MEASUREMENTS

Listing all possible applications of telluric current measurements is presumptuous and almost impossible. A tentative scheme is given here, which, perhaps, can provide a first approach to such a complex topic.

Detection of Electromagnetic Signals from Space

The Earth (including natural conductivity structures and man-made systems, such as communication cables and powerlines) can be treated as a receiving antenna, useful for monitoring the external origin electromagnetic fields. Communication cables of varying length can provide information on the spatial scale as a function of frequency of the external signal. See Meloni *et al.* (1983) for additional discussions of this point.

Prospecting of Underground Structures

Prospecting of underground structures is the most developed application of telluric currents. The methodology is quite extensive. There are two principal approaches, viz., Magneto-Tellurics (MT), which uses measurements of the two horizontal components of both the geomagnetic and the geoelectric fields, and Geomagnetic Depth Sounding (GDS), which uses measurements of all three components of the geomagnetic field. "Active" methods (see, e.g., Keller, 1976; Ward, 1983) make use of man-made electromagnetic fields. Such

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methods are well suited for shallow prospecting but can hardly be applied to deeper layers, because of the skin-depth phenomenon. Such required long-period electromagnetic waves cannot be generated practically. Long powerlines have been used for generating electromagnetic induction fields for prospecting purposes (e.g., Gill and MacDonald, 1967).

A distinction should be made between prospecting techniques that use the static geomagnetic field of the Earth and techniques that use electromagnetic induction effects. In handling the standard aeromagnetic and oceanographic magnetic surveys, whose purposes are to understand the static fields, the time-varying fields recorded at a ground-based site "close" to the area of the survey must be subtracted from the air or the ocean signal. This introduces some errors, whose actual values are often difficult to estimate (e.g., Reford, 1979). The time-varying component from such surveys can be used for geomagnetic depth-sounding studies (Gregori and Lanzerotti, 1979a).

Deep-Earth Studies

Telluric currents are likely eventually to be important tools for prospecting the deep structure of the Earth, thus providing valuable complementary information to that provided by seismic waves. A great advantage of GDS methods is that, while many studies concentrate on magnetic storm events, the studies can also be carried out using inducing signals during more quiet times, signals that are always in existence. The use of induced currents from natural electromagnetic waves for deep-Earth research is being pursued actively in a number of countries, particularly the Soviet Union. Recent reviews include books by Rokityansky (1982), Patra and Mallick (1980), Parkinson (1982), and Berdichevsky and Zhdanov (1984).

Tidal Phenomena and Water Flows

There are three types of tides: atmospheric, oceanic, and solid Earth. Atmospheric tides generate a large part of the external-origin inducing field of long period; oceanic tides produce a time-varying geomagnetic field associated with water flows; and solid-Earth tides can similarly produce a geomagnetic field because they can produce an eventual water flow that will produce a magnetic field. Theoretical and observational aspects of the phenomena have been discussed by Meloni *et al.* (1983).

Within the past decade extensive use of shorter undersea cables (such as those across the Dover Strait; e.g., Prandle, 1978) has been made for studies of tidal oscillations and water flow. Cables across the Irish Sea have been used for such studies (for example, Prandle and Harrison, 1975; Prandle, 1979). Geomagnetic disturbances can affect the measurement capabilities and, hence, results of such a cable-monitoring system. The data presented in Figure 16.13 are from chart recordings of the cable voltage on the Donoghadee-Port Patrick cable on a day of geomagnetic disturbances (Prandle and Harrison, 1975). The low-frequency variation in the voltage, spanning the record, is produced by tidal flow. The higher-frequency variations, produced by geomagnetic storm induction of currents in the cable, obscure the variations in such a manner that the data cannot be used reliably for water-flow information on such a day.

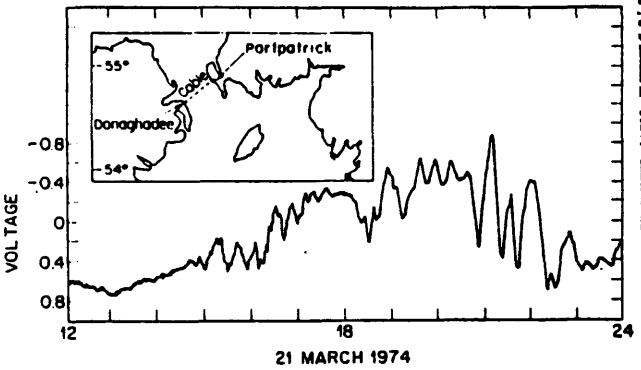

FIGURE 16.13 Cable voltage on the Donaghadee-Port Patrick cable on a geomagnetically disturbed day (from Prandle and Harrison, 1975).

Earlier, Wertheim (1954), in studying water flow across the Florida straits using the Key West-Havana cable, found occasional rapid variations in the cable voltage. He attributed these to geomagnetic effects and tried to model them using magnetometer data from the San Juan Observatory. Recent work in studies of the Florida current were reported by Larsen and Sanford (1985).

Earth's Astronomical Motion

The variation in the length of the day and the displacements of the positions of the geographic poles are among the most precise and fascinating topics in geophysics and have now become a vast discipline. The problem, however, of a possible role of telluric currents in producing a braking or an acceleration in the Earth's rotation or in displacing the Earth's poles appears still basically unsolved and/or is not considered important by many. This is discussed in some detail by Meloni *et al.* (1983) (and references therein), where also the possible

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use of a transatlantic communication cable is discussed as a possible experimental device to detect such an effect.

Earthquakes, Volcanoes, and Geodynamics

Since telluric currents are excellently suited for deep-Earth investigations, they are in principle also suitable for monitoring long-scale time variations as well. The most investigated aspect from this viewpoint is concerned with earthquake precursors (e.g., review by Honkura, 1981, and references therein). A clear distinction should be made among three different, possible types of phenomena: (1) geomagnetic effects that can presumably be said to be "very shallow" and are likely related to piezomagnetism, following changes in local stresses in the upper crust, which is an effect strictly local and can completely change in a distance of a few kilometers or less; (2) "shallow" effects that can be detected by ground resistivity changes or by suitably short-period MT or GDS investigations; and (3) "deep" or "very deep" effects that can be most suitably detected by means of long-period GDS investigations. This latter category of effects is more strictly related to telluric currents than are the first two types of effect.

Additional possible applications in this area include (1) slowly varying effects correlated with geodynamic and tectonic features, (2) shallow effects related to magma migration in volcanic areas, and (3) the monitoring of temporal variations in underground structures as related to fluid extraction (or reinjection). The shallow effects could, however, possibly be better detected by use of man-made electromagnetic fields than by means of natural fields. Telluric currents are also well suited for investigating ocean-bottom and geothermal areas (see Law, 1983; Berktold, 1983).

Communications

Within the last 10 to 15 years suggestions have been made that a natural waveguide in the Earth's crust, composed of the insulating layer of dry rocks sandwiched between the upper hydrated conducting and the underlying conducting hot layer, could be used for communication purposes. This suggestion, however, does not seem to have been followed by any known application. Existing literature is referenced in Gregori and Lanzerotti (1982). A practical problem is certainly concerned with the spatial nonuniformity of such a waveguide, the width and depth of which is undoubtedly widely varying (e.g, compare a cratonic area with a mid-oceanic ridge area) and is essentially unknown in many regions.

In a similar fashion, magma chambers in mid-oceanic ridges can be considered the natural "equivalent" of man-made submarine communication cables. The conductivities are such that the mid-Atlantic ridge is equivalent to about 1000 such cables in parallel (see Gregori and Lanzerotti, 1982).

An interesting communication experiment related to artificial telluric currents was reported by Fraser-Smith *et al.* (1977). They operated, as a transmitting antenna (using a simple car battery), a circuit loop composed of seawater encircling a small peninsula in a nearly enclosed area.

Biological Effects

The response of living species to electromagnetic fields (such fields being either responsible for, or a consequence of, telluric currents) is a difficult but important problem. Several examples discussed in the literature include the induced currents in a tree produced by geomagnetic fluctuations (Fraser-Smith, 1978) and the use of magnetic fields for orientation by aquatic bacteria (e.g., Blakemore, 1975) and by migrating birds (e.g., Moore, 1977; Larkin and Sutherland, 1977; Alerstam and Högstedt, 1983; Beason and Nichols, 1984). Telluric currents could play a role in some control of fish (e.g., Leggett, 1977; Kalmijn, 1978; Brown *et al.*, 1979; Fainberg, 1980; Fonarev, 1982). Magnetite crystals have been reported as isolated from a sinus in the yellowfin tuna (Walker *et al.*, 1984). Enhanced DNA synthesis has been reported for human fibroblasts exposed to magnetic-field fluctuations with frequencies and amplitudes similar to many geomagnetic occurrences (Liboff *et al.*, 1984). The entire area is fraught with controversy, particularly that related to magnetic effects, and has been reviewed by Parkinson (1982) and commented on by Thomson (1983).

CONCLUSIONS

Historically, telluric currents were intensively investigated in the second half of the nineteenth century, particularly because of their influences on long telegraph conductors (see Appendix). The intrinsic difficulties encountered in obtaining fundamental understanding, basically related to the several causes that can be coresponsible for the observed effects, discouraged geophysicists from pursuing such investigations vigorously. However, with respect to a century ago, large improvements have been made in a number of areas, including recording techniques, density of available observations, international data exchanges, computational facilities, mathematical methodologies, and general geophysical

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understanding. Hence, research in this area would appear to be poised for achieving significant new understanding.

Investigations using, and studying, the telluric currents suffer from three principal drawbacks: (a) the spatial coverage by the recording equipment is often too sparse compared to the extent and spatial gradients of the phenomena under investigation; (b) there is not general agreement on the experiment and analysis methodologies, often leading to difficulties when comparing the results from different investigations; and (c) the use, within the general understanding of deep geophysical structures, of the information provided by electromagnetic techniques is often neglected. It is hoped that these deficiences will be ameliorated in future telluric current work.

Telluric currents are a relevant part of our electromagnetic environment, both as a consequence of the time-varying natural electromagnetic field and as a consequence of moving seawater. Human interactions with telluric currents and their related effects are definitely important, even though such interactions are only incompletely understood. A considerable effort on geomagnetic source characteristics and Earth conductivity characteristics are required before a satisfactory and comprehensive understanding can be achieved. The critical role of telluric currents within the geophysical environment, encompassing such areas as the Earth's astronomical motion, to current channeling, to eventual implications for ocean-water motion, still appears as a challenging frontier. As well, further assessments must be made on the actual role of telluric currents, as well as of the geomagnetic field *in toto*, on biological systems. The field is multidisciplinary and fascinating. Substantial achievements can be expected in the near future.

ÆTHERFORCE

VRIL DETRITUS AND TELEGRAPH LINES

Electrical disturbances, however, of a kind which do not manifest themselves in discharges of lightning, or involve life or ordinary property in danger, are quite sufficient to derange the operations of the telegraph. During snow and hail-storms, whilst dry fogs are prevailing, when the aurora borealis appears, and in truth during most meteorological changes, much electricity is developed in the atmosphere. It is sometimes directly transferred to the telegraph-wires, but as frequently its action is only indirect. A body in which free electricity is in any way developed determines a similar electrical condition in an insulated mass of metal near it, exactly as a magnet induces magnetism in pieces of iron placed in its neighbourhood. Thus an electrical cloud floating along above the extended wires generates a current of electricity in them; or, to speak more strictly, causes the electricity naturally present in a latent state in the wire, to become free and move along the metal. The currents which thus travel, as well as those which are directly transferred from the atmosphere, have the same effects on the index-needles and signal-bells, as the electricity purposely sent along the wires from the battery. The needles are swung unceasingly to and fro, or remain for hours deflected to one side. The bells ring violently at irregular intervals, or stop only when their weights are run down. Signals cannot be transmitted at all when atmospheric electricity is thus largely developed; and they become more or less confused whenever it is sufficiently powerful to affect the index-needles.

Apart altogether from its practical importance, there is something exciting in the contemplation of these strange atmospheric influences. It must be not a little startling to the drowsy occupant of some solitary telegraph station, to be roused from his midnight slumber by the spectral clanging of his signal-bell, bidding him quail at the wild quiverings of the magnets, swayed plainly by no mortal hands. An imaginative man

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might then recall the legends which tell of disembodied souls sent back to this earth, to divulge some great secret of the world of spirits, and seeking in vain for means of utterance, which shall be intelligible to those in the body. A philosopher, too, might accept and interpret the legend. For it is sober truth, that the apparently aimless and meaningless movements of the magnetic needles when vibrating at such times, are, after all, the expressive finger-signs of a dumb alphabet, in which nature is explaining to us certain of her mysteries; and already, too, we are learning something of their significance.

Peculiar difficulties have attended the transmission of electric signals through some of the railway tunnels. Those have been traced in some cases to the effect of the moisture trickling down the walls in destroying insulation; and the wires have in consequence been coated, like those of the marine telegraph, with gutta percha. In other cases the index-needles at the stations nearest the tunnels have remained set to one side for considerable periods. This has been referred to the influence on the tunnel wires of electrical or magnetic disturbances in the strata in the neighbourhood of the tunnel. If this view be well-founded, it would be wise to make the telegraph-wires where they pass through the tunnels, of copper, and not of iron, as the non-magnetic character of the former metal makes it less susceptible of electrical excitement. A wire cannot be magnetic and electrical in the same direction at the same time. If a telegraph-wire become magnetic in the direction of its length, like a long compass-needle, it will resist the passage of comparatively feeble electric currents, which would have traversed it had it been non-magnetic. This fact has not, perhaps, been sufficiently considered in the explanations which have been given of the derangements of the telegraph. Iron becomes so readily magnetic, that the telegraph-wires, when made as they generally are of that metal, cannot in certain circumstances escape being magnetised by the earth. Now that

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railways are projected in India, it may not be amiss also to notice that near the Equator iron rods or wires lying north and south after a time become magnetic. And wherever, in other regions, the wires are extended in the direction of the magnetic dip, the same effect will occur. The cheapness, elasticity, and strength of iron, however, more than counterbalance the inconveniences under notice.

Many of the evils referred to are avoided in the Prussian telegraph, which has also been adopted in Saxony and Austria. In it the wires, which are of copper, are not stretched along posts, but covered with gutta percha and buried at some little depth in the ground. Snow-storms, heavy rains, and fogs do not destroy the insulation of the wires, as they do that of those suspended in the air; nor are the subterranean wires deranged by atmospheric electricity, or subject to the influence of thunder-storms. But it does not appear that they are indifferent to the disturbing effect of the aurora borealis, which often completely suspends the working of the aerial telegraph; and it may be suspected that alterations in the intensity of the earth's magnetism, which we know are constantly occurring, will affect the buried much more than the suspended wires.

In favour of the subterranean telegraph, it is alleged that, though at first more costly, in the end it is much cheaper than the aerial one, as the posts which the latter demands require renewal at intervals, and the suspended wires, in consequence of their exposure to great variations of temperature, and the vibrations determined in them by the impulse of the wind, the passage of railway trains, and the transmission of electric currents, undergo a change in structure, and become so brittle as readily to snap across. On the English railways, however, such brittleness as the Prussian engineers refer to has not been observed to occur in the suspended wires, although it is not to be denied that both in the aerial and subterranean telegraphs the wires slowly undergo a molecular change, which

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will alter their power to convey electricity; and that the aerial arrangement is exposed to more disturbing agencies than the subterranean one.

On the other hand, it is acknowledged that it is more difficult to secure the insulation of the buried wires, and where this is defective it necessitates the employment of more powerful batteries to force the current along the imperfect conductors. Further; the buried wires are with difficulty reached when deranged, and each wire laid down requires a trench to be prepared for it, whereas in the aerial telegraph one post will carry any number of wires. The encasing of the wires also in gutta percha, determines certain electrical conditions similar to those of a Leyden jar, which do not occur in the suspended wires, and which may interfere with the action of the embedded wires as transmitters of electricity.

The Prussian subterranean telegraph has only been in use since 1848, so that its peculiarities and defects are much less known than the English aerial one, which has been at work since 1838. A further period, accordingly, must elapse before we can decide which is the preferable arrangement. Had gutta percha been as well known in 1838 as it was ten years later, subterranean telegraphs would long ago have been constructed in England, where they were abandoned from the difficulty experienced in finding a suitable and sufficient insulating substance with which to cover the buried wires. A subterranean telegraph, or rather set of telegraph-wires, is about to be laid down in England by a new company, so that before long we shall be able to contrast the working of the two methods at present in vogue.

AETHERFORCE

VRIL DETRITUS IN MEASUREMENTS...

INCAPABLE OF PERSONALLY EXPERIENCING VRIL

PHYSICISTS CAN MERELY MEASURE THE BY PRODUCTS

OF VRIL PASSAGES.

THESE ARE NEVER SYMMETRIZED WITH RESPECT TO VRIL THREAD PASSAGES

AND ARE THEREFORE UNRELIABLE IN DEFINING EXACT DIRECTIONS

OR INTENSITIES OF VRIL

1540	First reported measurement of geomagnetic declination and dip in London (as discussed, for example, in Malin and Bullard, 1981; Barraclough, 1982). For the early history of geomagnetism, including the works of Gilbert and Gauss, refer also to Mitchell (1932a, 1932b; 1937), Chapman (1963), Mattis (1965, Chap. 1), Parkinson (1982, Chap. 6), and Merrill and McElhinny (1983).
1600	First modeling of the geomagnetic field by Gilbert's (1600) terrella (Malin, 1983).
1821	Davy (1821) suggested the existence of Earth currents that, he argued, could be responsible for variations in the geomagnetic declination (Burbank, 1905).
1832	Faraday (1832) envisaged for the first time the existence of induced currents in water, related to water flows and tides. He also attempted, without success, to detect, from the Waterloo Bridge, such currents flowing within the Thames. Gauss (1833) reported the first measurements, on May 21, 1832, of the absolute value of the geomagnetic field (Malin, 1982).
1846-1847	Barlow (1849) made the first observations, in England, "on the spontaneous electric currents observed in the wires of the electric telegraph."
1848	Matteucci detected induced currents in the telegraph wire between Florence and Pisa, while Highton observed the same effect in England (see section on Communication Cables).
1850	Similar effects were reported in the United States.
1859	A telegraph line in the United States was reported operated by means of the natural induced currents during geomagnetic disturbances on September 2.
1862	Lamont (1862) reported one of the first experiments to specifically address Earth currents (carried out in the Munich Alps).
1865	Experiment by Airy (1868) on two wires of 13 and 16 km from Greenwich.
1867	Secchi (1867) reported measurements on two almost orthogonal telegraph lines of lengths 58 km (Rome-Arsoli) and 52 km (Rome-Anzio).
1881	The Electrical Congress, meeting in Paris, recommended that certain short lines be set apart in each country for the study of Earth current phenomena and that longer lines be used as frequently as possible (Burbank, 1905).
1884-1887	Four complete years of records on two telegraph wires in Germany (262 and 120 km) investigated by Weinstein (1902) and Steiner (1908).
1883-1884	Blavier (1884) recorded, for 9 months, Earth potentials on five long telegraph lines extending from Paris, ranging in length from 200 to 390 km. See also Counil *et al.* (1983).

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On July 2, 1729, Stephen Gray proved that electricity would travel from one place to another.

ÆTHERFORCE

How do physical changes in the sun produce auroræ, and influence the magnetic needle on the earth?

Light and heat are now universally admitted to be sensations produced by vibratory motion of a material body, the luminiferous ether; and from the known phenomena of light and heat, we infer that this body, the ether, possesses elasticity and inertia, but not gravity. (See "Brande's Encyc., Art. 'Light.'")

We may assume, therefore, that infinite space is pervaded by an inert, but non-gravitating, elastic fluid; and that it is through the medium of this fluid that all our knowledge of the universe outside the little world we inhabit, is derived; and, also, a very large portion of the knowledge we get of our immediate surroundings. The ether being inert, elastic, and non-gravitating, will, necessarily, be less dense within and immediately around revolving bodies, than at a distance from them; for, being inert, it will, from centrifugal force, recede from the center of rotation; there will, therefore, be a continual tendency to the formation of an ethereal vacuum along the axis of rotation, and an equilibrium along the center of rotation can only be sustained by an in-flowing current of ether from the polar regions of the revolving body. We have, therefore, of necessity, within and about all revolving bodies, not only the phenomena of light and heat, from ethereal vibrations, but, also, an ethereal motion of translation, and this motion of translation will always be outward about the equator and middle latitudes, and inward about the poles. We might, *a priori*, be led to expect some tangible indication of this ethereal motion of translation about the earth, as the earth has a tolerably rapid rotary motion. Have we any such indications? I answer, we have in the phenomena of magnetism and the auroræ.

Science has hitherto failed to assign any rational cause for the phenomena of magnetism. In order that we may understand how a motion of translation of the ether may produce the phenomena of magnetism, we must assume that, though the vibratory motion of the ether is arrested or reflected by all opaque bodies, yet, in its motion of translation, it passes freely through most bodies, but the molecules of a few bodies, such as iron and steel, may be so arranged as to be impervious to the ether in one direction, and yet transmit it freely in a direction at right angles with the impervious axis. Let such a body be balanced on a pivot, and, like a vane, it would indicate the direction of an ethereal current by the impervious axis assuming a direction at right angles with such current. We have here, obviously, a possible physical explanation of magnetism.

When the atmosphere flows through a forest of trees, we hear an audible sound, which is the result of vibratory motion of the air produced by interference with the trees. So in the upper regions of the atmosphere, an ethereal current might encounter sufficient interference from the molecules of the atmosphere to produce vibratory motion of the ether of sufficient intensity to be recognized by the eye as the auroras.

Let it be granted, now, that we have assigned the true cause of magnetism and the auroras, should we expect these phenomena to indicate any great physical movements in the sun?

ÆTHERFORCE

If we consider electricity as a force, we must consider the normal atomic state to be that of comparative rest. Regarding an atom as a point in a line of force, the force tending towards that atom will be positive or negative to the force tending from the atom; positive and negative being used in the mathematical sense as referring to opposite directions. Electricians have termed that the positive current which flows from the copper pole to the zinc pole, or, inside the battery, from the zinc plate to the copper plate.

If the reader will make the following simple experiment, he will see that the positive current is the only visible current in a closed galvanic circuit. Take a battery and connect a piece of wire one end to each pole; sever the wire at any point, and apply the two ends to the tongue. On the side touched by the wire attached to the copper pole a sharp pricking sensation will be felt, and on that side only. Insert a galvanometer between the severed ends, and mark the direction of the index. Join up the severed wires, and insert the galvanometer in any other part of the circuit, the index will still point in the same direction, proving that there is but one current—that from the positive, or copper, pole. It would seem, then, that when electrical force is developed by chemical decomposition, the normal state of rest is destroyed, and force is imparted to the particles of the collecting plate and thence to line.

There is ground, then, for the supposition that the current flows from the seat of action in one direction only. In further proof, Faraday's experiment with a silver-copper couple may here be quoted. Let two plates, one of silver, the other of copper, be placed in a vessel containing sulphuret of potassium. The needle at first deflects in a direction which shows that the copper is the positive element of the pair; it then gradually returns to its first position, and again deflects in the opposite direction, showing that the silver is now the positive element. After some time it returns, and again deflects in the opposite direction, and goes on thus changing. If the plates be examined during these changes, it is observed that sulphuret of silver is formed when the silver plate is positive, and sulphuret of copper when the copper plate is positive.

Nowhere is there any indication of more than one current. What reason, then, is there to suppose electricity a dual force?—in a closed galvanic circuit we have seen that there is but one force exerted in one direction. The only phenomenon that can be supposed to give rise to the idea that two forces are set free occurs when earth is made to complete the circuit. The battery then appears to draw up a current from earth to zinc—note that the direction is still the same—as well as send a current from copper to earth. Before we suppose another force to account for this flow, let us see if it could not be produced by the already existing force. Imagine that the wire is a tube of water and that, at the point indicated by the battery, a force is applied which imparts motion to part of the water on the tube. We know that the rest of the water will flow in the same direction.

To return to our conducting wire: electrical force has been, and is being generated, the atoms in one part of the circuit are impelled forward to the limit of their space, and in their rear, so to speak, a kind of vacuum has been formed, having a tendency to increase, which the atoms in the other portion of the conductor endeavor to fill up, and, in the endeavor, are set in motion.

If this theory be true, it has the advantage in its favor that it does away with the complication of currents so difficult to the tyro in electrical science. Above all should we remember the aphorism, *Natura simplex est.*

Perhaps the greatest phenomenon of electricity is that it both produces, and is produced by, magnetism. Let us then define electricity to be, a force capable of generating, and being generated by, magnetism.

In a short time, the writer hopes to submit to his readers the application of this definition and of Ampere's beautiful, because practicable, theory to the phenomenon of static electrical force, and induction.—*Electric Telegraph and Railway Review.*

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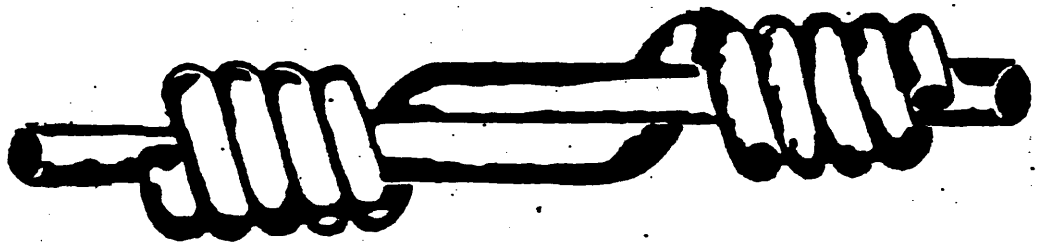


SPLICED WIRES

Electric wires are joined by splicing after the ends have first been scraped. Scraping removes the dirt and oxide which is a non-conductor. The joint or splice is soldered to insure a good connection which will not heat.

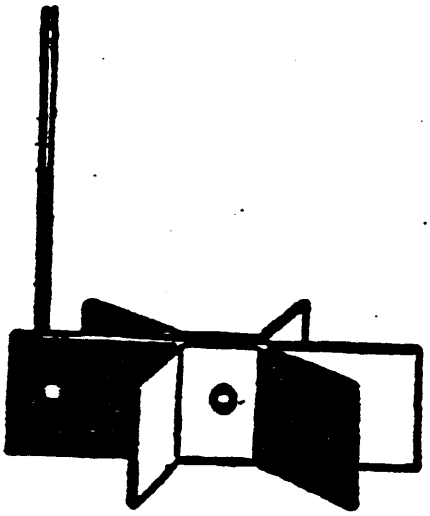
SPLICED LINES EMPLOY HELICAL CONNECTIVITY

VRIL THREADS ENTWINED WIRES, POLES, METAL RODS AND BARS

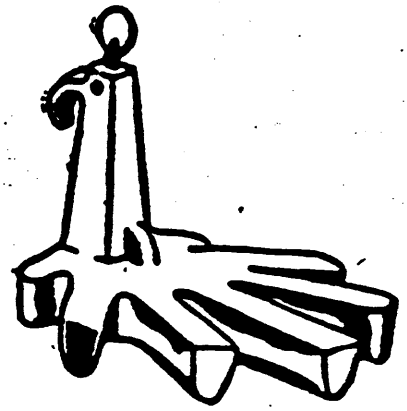
VRIL ENTWINED METALS DISPLAY INERTIAL DETRITUS

WHICH ENTERS RECIPIENT TERMINALS

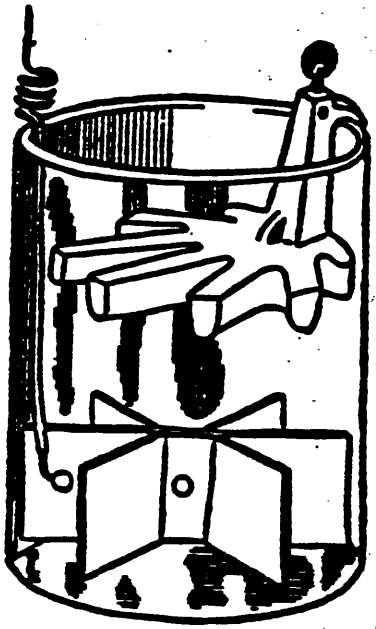
ÆTHERFORCE



Copper



Zinc



GRAVITY OR "CROWFOOT" CELL

This is the type of cell which once supplied current for telegraph lines.

CHEMICAL BATTERIES ARE CONDENSERS

IN WHICH VRIL TRANSACTIONS ARE ENGAGED THROUGH MATERIAL CONTACTS

VRIL-STRONG MATERIALS OF VARIOUS INERTIAL PRODUCTIVITY

MAY BE ARRANGED TO YIELD VARIETIES OF DETRITAL COMPONENTS

ELECTRICAL DETRITUS IS PRODUCED AMONG SPECIALLY ARRANGED MATERIALS

WHERE INERTIAL DETRITUS MOVES IN A SPECIFIED MANNER

EIDETIC WORLD TRANSACTIONS

PRODUCE PONDERMOTIVE DIRECTIONALITY OF INERTIAL SPACE

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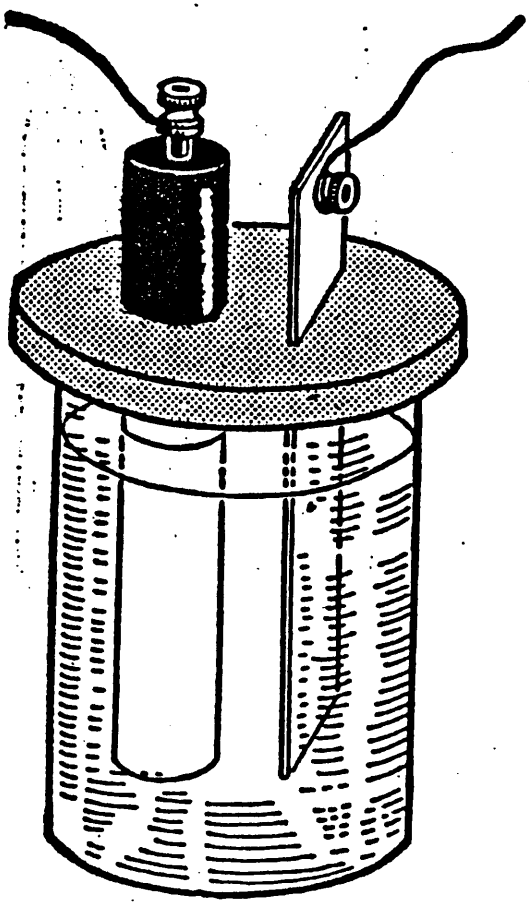
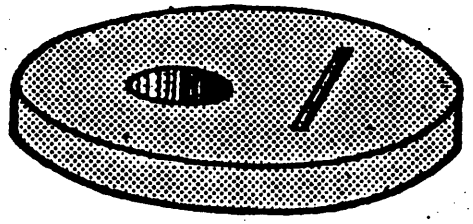
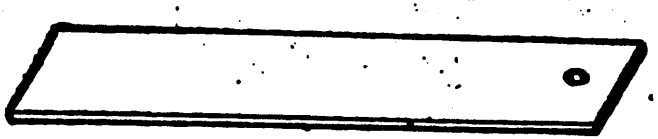
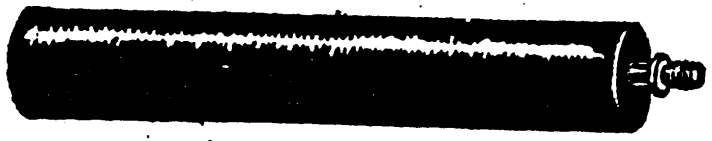




WOODEN TOP



ZINC STRIP



CARBON ROD

AN EXPERIMENTAL LECLANCHÉ CELL

WHITE RAYSHEATH MATTER IS INERTIAL PRODUCTIVE MATTER

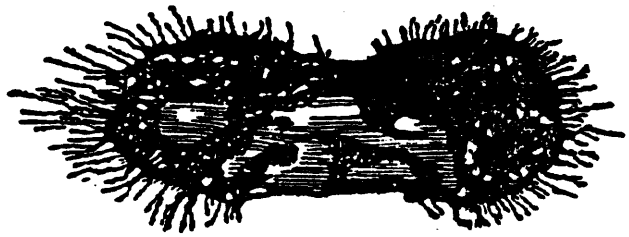
COPPER PROJECTED TRANSACTIONS IMPACT ZINC

INCIDENTALLY RELEASING INERTIAL DETRITUS

COPPER BECOMES INCIDENTALLY DETRITUS-ABSORPTIVE

ETHERFORCE

One of the most surprising things about a lodestone is its ability to give magnetism to steel. A piece of hardened steel itself becomes a magnet if it is rubbed on a lodestone. One of the most amazing things of all is the fact that a lodestone does not lose any of its own magnetism when it gives its ability to a piece of steel.



THE FIRST MAGNET

The first magnet was a hard black mineral called lodestone. This one has been dipped in iron filings and the filings are clinging to the ends in tufts.

LODESTONE IS A SPECIAL VARIETY OF IRON CRYSTAL

VRIL THREAD PROJECTIONS SHOCK LODESTONE AT "SOUTH POLE"

MAGNETIC PATTERN STANDS OUT IN CONTINUOUS VRIL IMPACT

VRIL THREADS TUNNEL THROUGH IRON

MAGNETS ARE ONLY "PERMANENT" VIA VRIL CONDUCTION

VRIL PROJECTIONS SUSTAIN INERTIAL (MAGNETIC) POLARIZATION-PATTERNS

MAGNETIC PATTERNS DISPLAY MICROIDAL IMPERFECTIONS DUE TO IRON CRYSTAL

LODESTONE RODS AND BARS INTERNALIZE VRIL CONDUCTION

GEOMETRIC CONFIGURATIONS DIFFERENTIATE VRIL PATHS FROM INERTIAL PATTERNS

U-SHAPED MAGNETS DIFFERENTIATE VRIL IRON CONDUCTIVE PATH

FROM SPECIAL INERTIAL PATTERN

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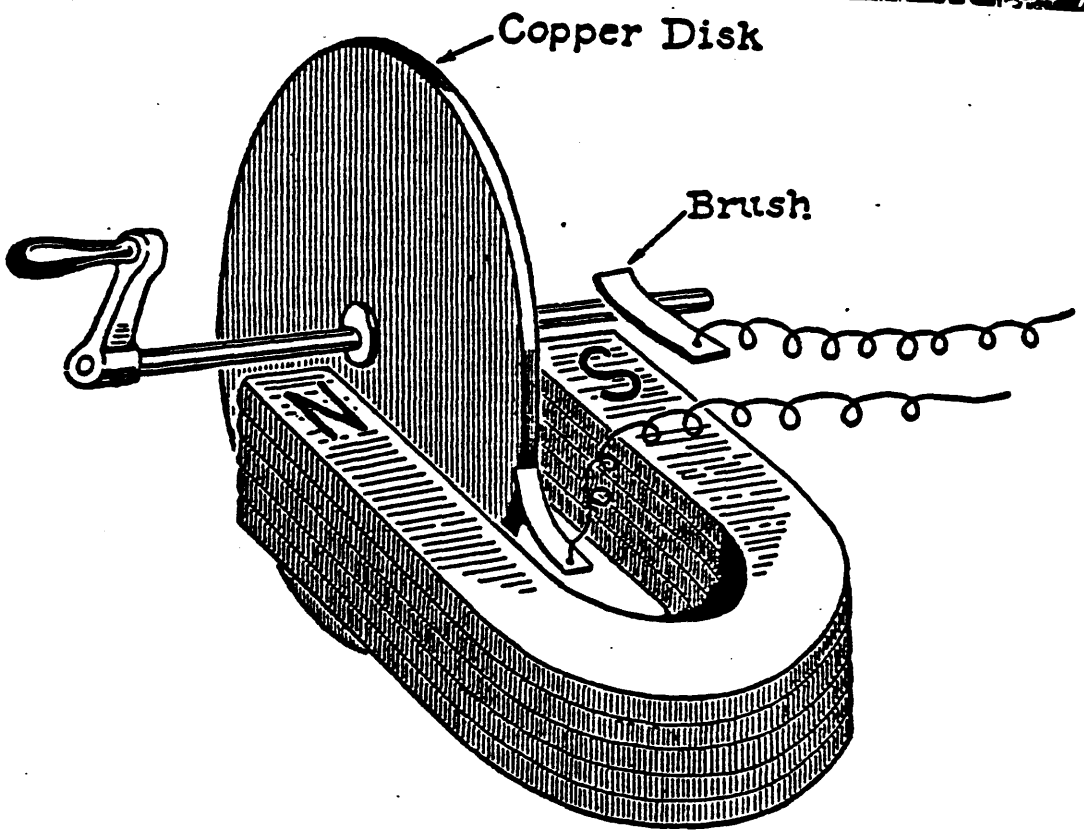


FARADAY'S GENERATOR

The huge generators which supply electric current for lighting a whole countryside had their beginning in this simple affair devised by the famous Michael Faraday.

VRIL COOPERATES IN SYSTEMOLOGIES

MOTIVE IMPULSES CREATE VRIL DISCONNECTIVITIES IN MATTER

VRIL THREADS ARE DISCONTINUOUS IN COPPER DISK

INERTIA ENTERS DISK FROM EDGES IN WHITE SHIMMERINGS

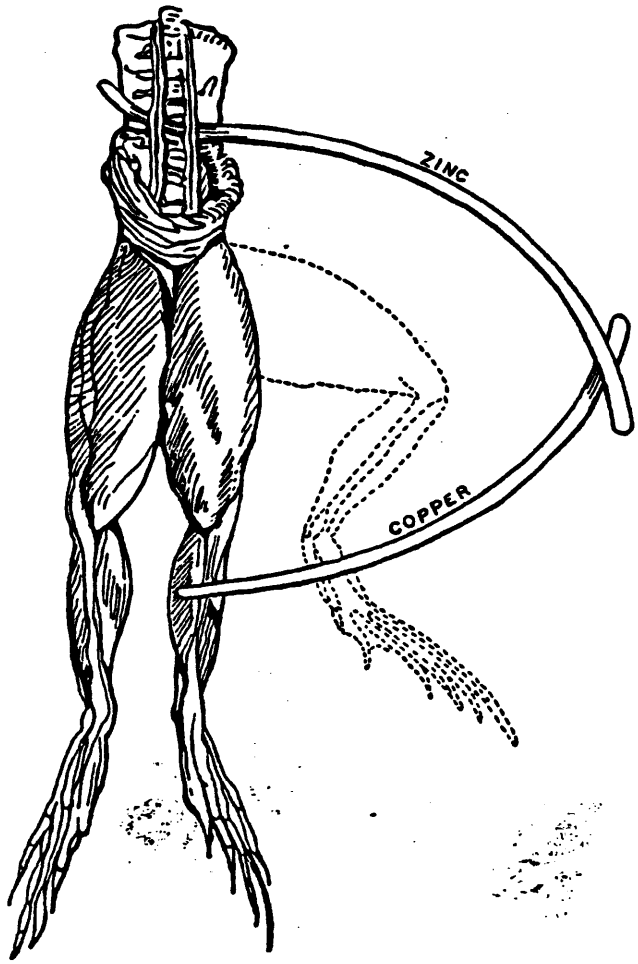
VRIL POINT SUSTENANCE IS SHUNTED THROUGH IRON YOKE

INERTIAL MAGNETIC PATTERN GEOMETRICALLY DIFFERENTIATED FROM VRIL

NEUTRAL COPPER-CONCENTRATED INERTIA TRAVERSES MAGNETIC PATTERN (90 DEGREES)

ÆTHERFORCE

GALVANIC DISCOVERIES INCLUDED THE FINDING THAT METALLIC CONFIGURATIONS
ACHIEVED EQUIVALENT RESPONSES IN ORGANISMS
AS WHEN EXPERIENCED THROUGH AERIAL-GROUND CONNECTIONS.

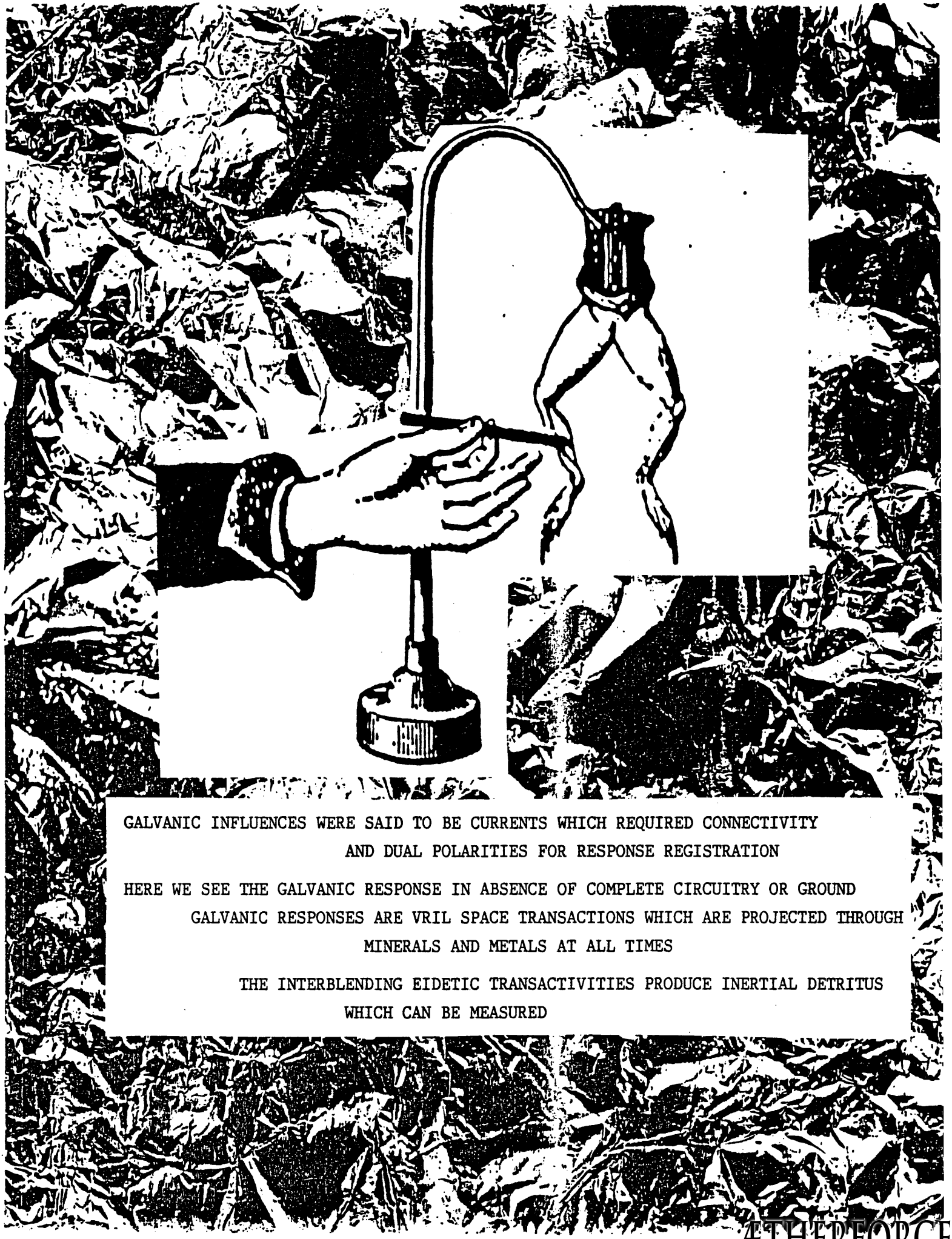


GALVANI'S FAMOUS DISCOVERY

GALVANI DISCOVERED MYSTERIOUS NON-ELECTRICAL IMPULSES WHICH SUDDENLY
WHICH SUDDENLY EXPRESSED UNKNOWN VISCERAL TRANSACTIONS OF THRILLING CONTENT

SIMILAR RESPONSES WERE EXPERIENCED AMID SPECIALLY ALIGNED METALLIC PLATES
IN ABSENCE OF PHYSICAL CONTACT

ÆTHERFORCE



GALVANIC INFLUENCES WERE SAID TO BE CURRENTS WHICH REQUIRED CONNECTIVITY AND DUAL POLARITIES FOR RESPONSE REGISTRATION

HERE WE SEE THE GALVANIC RESPONSE IN ABSENCE OF COMPLETE CIRCUITRY OR GROUND

GALVANIC RESPONSES ARE VRIL SPACE TRANSACTIONS WHICH ARE PROJECTED THROUGH MINERALS AND METALS AT ALL TIMES

THE INTERBLENDING EIDETIC TRANSACTIVITIES PRODUCE INERTIAL DETRITUS WHICH CAN BE MEASURED

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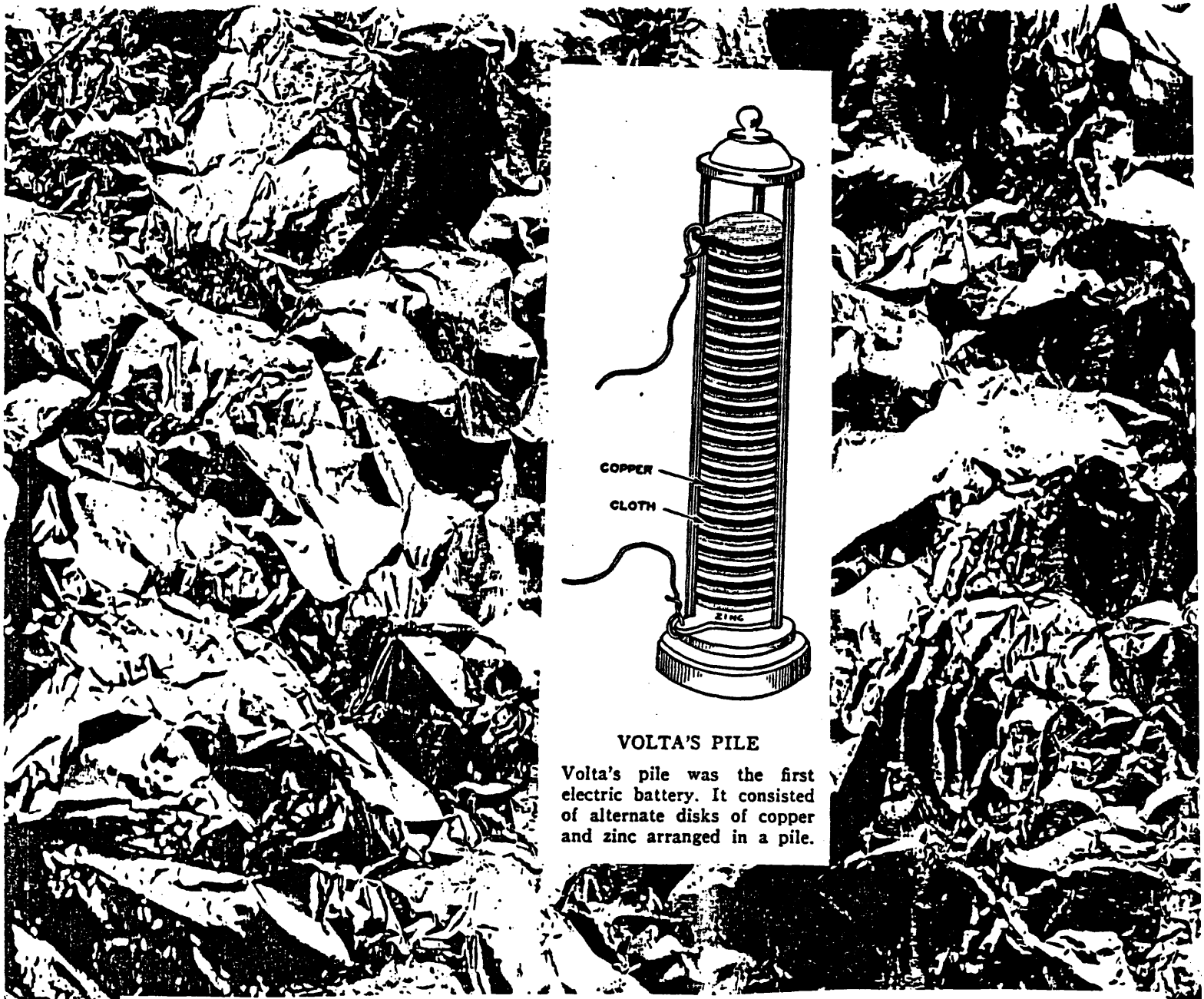

VOLTA'S PILE

Volta's pile was the first electric battery. It consisted of alternate disks of copper and zinc arranged in a pile.

GALVANIC CONFIGURATIONS YIELD VERY LITTLE INERTIAL DETRITUS AND STRONG VRIL CONTENT

VOLTAIC CONFIGURATIONS USE SPECIAL MATERIALS TO PRODUCE
HIGH INERTIAL CONCENTRATIONS IN TERMINALS OF CONTACT

GALVANI NEVER CONFRONTED VOLTA ON THIS ISSUE...
BUT INSISTED THROUGHOUT HIS LIFE THAT HIS OWN DISCOVERY
HAD NOTHING TO DO WITH THOSE MADE BY VOLTA

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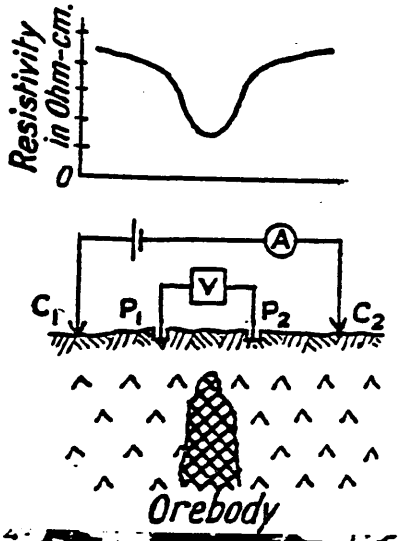

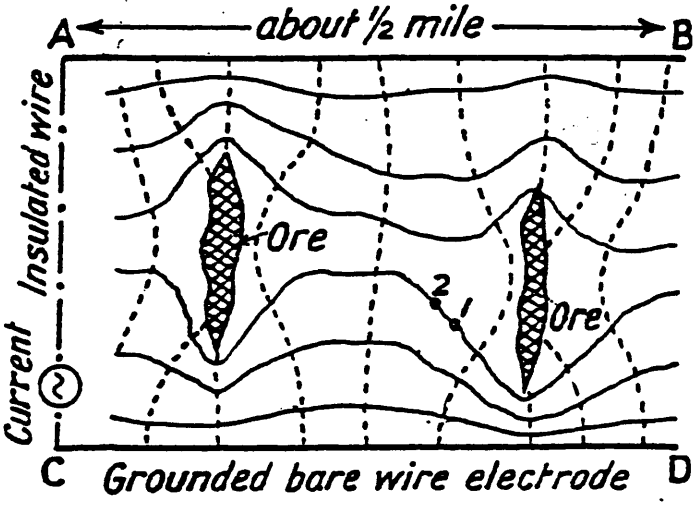

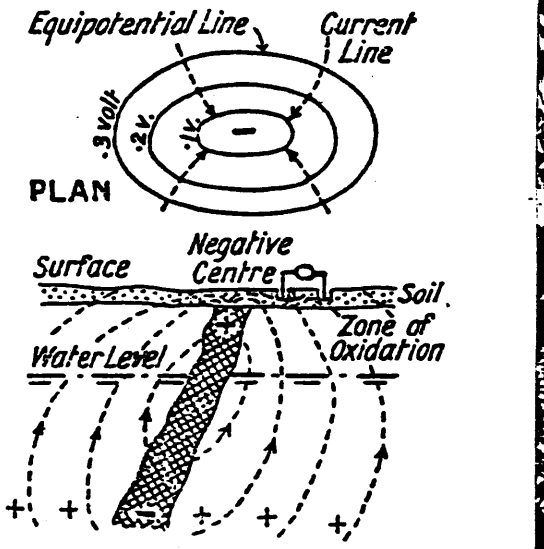

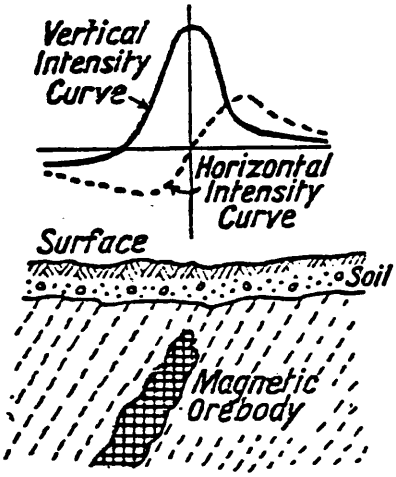

TELLURIC EXPLORATION UTILIZES VRIL GENERATED INERTIAL DETRITAL PRODUCTS

TELLURO-ELECTRICAL CURRENTS ARE PROJECTED ON VRIL EIDETIC TRANSACTIVE AXES

STUBBLEFIELD DESIGNS HAVE FOUND THEIR WAY INTO PROSPECTING

TELLURO-ELECTRICAL CURRENTS CONTAIN UNUSED VISCERO-EIDETIC CONTENT

ORE BODIES, LODES, MINERAL DEPOSITS AND CRYSTALS PROJECT POWERFUL

TELLURO-INERTIAL MEASUREMENTS NEVER REVEAL VISCERO-EIDETIC CONTENTS

VRIL COMPONENTS AND INERTIO-DETRITAL ENTOURAGE PROJECT INTO DISTRICTS

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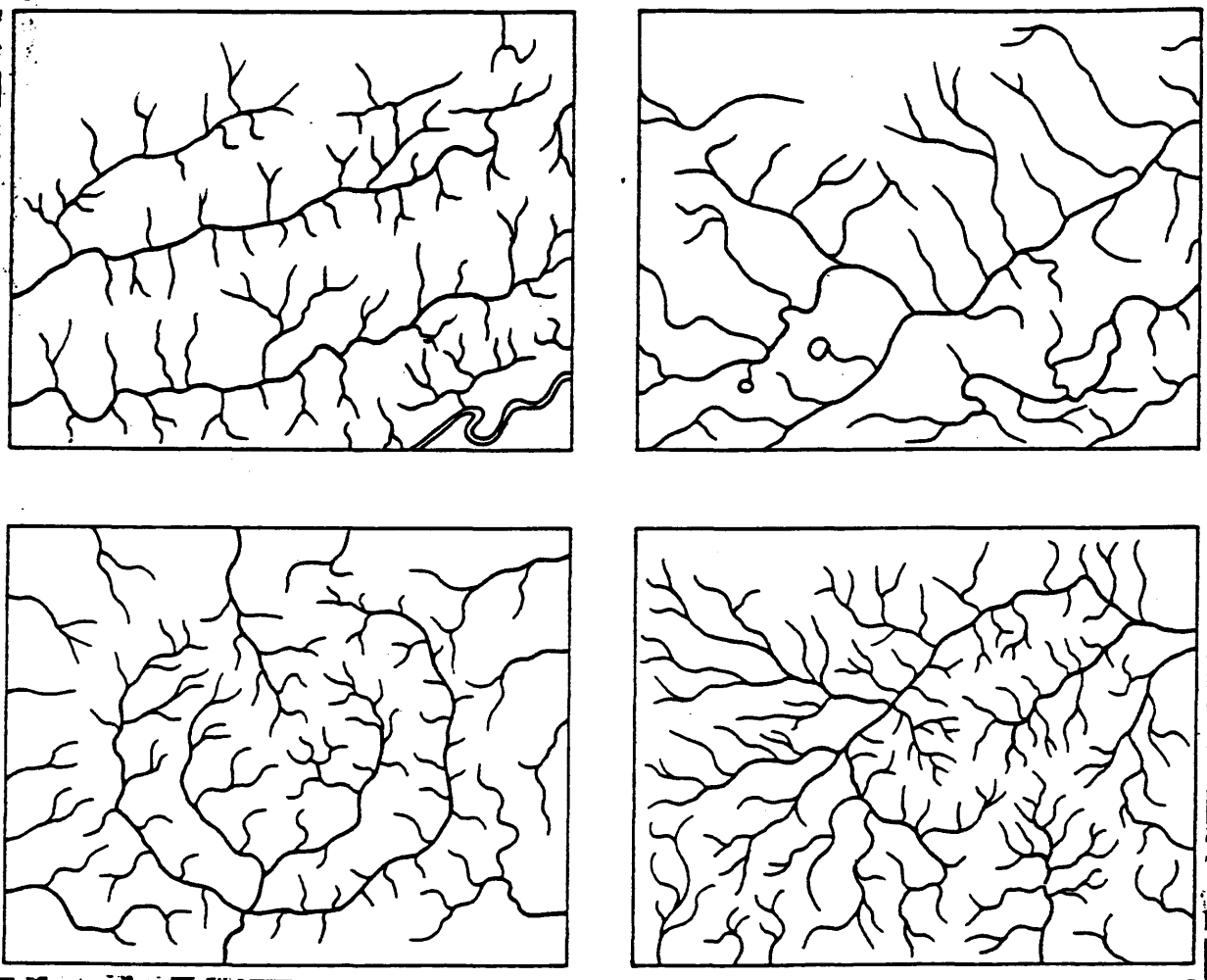

VRIL TEMPLATE ACTIVITIES GUIDE EVERY NATURAL MANIFESTATION

VRIL DENDRITIC PATTERNS EMERGE REGARDLESS OF MANIFESTATION AND SPECIES

INERTIAL DETRITUS CONFORMS TO VRIL GENERATIVE DENDRITIC FORMS OF CAUSE

AETHERFORCE

The Aurora and the English Telegraphs.

Mr. Culley, Engineer of Telegraphs, writes to the London *Times*:

"As public attention has been directed to the effect of the aurora on the telegraphs, perhaps you will permit one who has been connected with the telegraph from the very first to explain in what manner the transmission of messages is interfered with, and what means are used to keep up the communication.

"The aurora is supposed to be caused by a flow of electricity through the atmosphere at a very great hight, where the air is extremely rare.

"It is, in fact, a kind of lightning, differing from ordinary lightning in being a gentle and gradual flow instead of a violent and sudden discharge.

"The same cause which produces the aurora produces also currents which flow from one part of the earth's surface to another; and, as a telegraphic wire is always connected to the earth at each end, a portion of these currents must necessarily pass through the wire from one station to the other, provided the two stations happen to lie in their course, which is usually, though not always, nearly east and west.

"These so-called 'earth currents' are frequently very powerful (they were specially so, as might have been expected, during the late brilliant displays), but what is more troublesome still, they constantly vary in strength, and also in direction, and, consequently, make it impossible to read a message.

"They also affect the mariners' compass, but not sufficiently to be visible, except under special arrangements. They were powerful enough, however, on Tuesday evening, to deflect the magnet of a Thomson galvanometer, which is really a compass needle very delicately suspended, as much as 200 divisions when it was not connected to any wire whatever.

"It will be obvious, from what has been said, that some telegraph wires are more disturbed than others. Those running nearly east and west suffer most. It will also be readily seen that if the connection with the earth can be dispensed with the currents will not enter the wires.

"When there are several wires available between the two stations the earth connections are cut and the wires are looped, so as to use one of each pair as a return wire in place of the earth, thus forming a complete metallic circuit. But, although this plan is effective, it will be seen that it enables us to use only one half of the instruments affected. At the central office, on Tuesday, we were obliged to loop fifty wires in this manner, losing at once twenty-five circuits.

"We can also connect two wires so as to throw the terminal stations out of the line of disturbance, but, as the direction of the earth current is seldom constant, this method does not give very good results.

"It is also possible in some cases to divide the wire at both ends, introducing a condenser, or very large Leyden jar, and signaling by inductive discharges. This answers perfectly for a cable, but has not at present been found effective for land wires.

Grand Auroral Displays.

MESSRS. EDITORS:—The year 1870 will long be remembered by the inhabitants of the United States, for the great number of brilliant auroral displays; and while we could hardly conceive of anything that would equal those of the past September, last evening's exhibition will far excel any of its predecessors. The day had been cool, with frequent showers, but towards evening had almost entirely cleared away. At 6:30 a heavy wind commenced blowing from the W. S. W., carrying before it vast quantities of thick black clouds, that drifted in an E. and E. S. E. direction, entirely covering the northern heavens, and at intervals breaking forth in flashes of the most vivid lightning. The heavens from the zenith to the northern horizon, were tinged with a bright green shade, alternating with that of a beautiful rose color, through which the stars twinkled with a pale yellow luster. The N. W. and N. E. points of the horizon had the most decided tinge of red; while the direct N. that of the green. The rays at times extended to the Dolphin. The intensity of the display was lessened by the brilliancy of the moon, which was just rising, and had it not been for this, the sight would have been magnificent. The display must have been visible over the greater part of the Northern States, and at an hour when every one could witness it.

Chicago, Ill., Oct. 15th. H. H. BADGE.

TELLURIC EARTH CURRENTS ARE NOT ELECTRICAL IN NATURE

ELECTRIC EARTH CURRENTS ARE INERTIO-DETRITAL PRODUCTS OF VRILLIC EXCHANGES

PRIMARY TRANS-REGIONAL EFFECTS ARE NEVER ELECTRICAL: THEY ARE MAGNETIC.

VRIL EMPOWERS MAGNETIC PATTERNS

VRIL SURGES CAUSE CORRESPONDING EARLY MAGNETIC FLUXIONS

SUBSEQUENT ELECTRICAL DETRITUS

FOLLOW AFTER CERTAIN TIME INTERVALS

PERSONAL EXFERIENCE REGISTERS DEEP VRIL DISTURBANCES WHICH PRECEDE AURORAE

ÆTHERFORCE

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Earth Currents.

THE Astronomer Royal was kind enough to show me the permanent photographic records of earth currents during the great magnetic storm on February 20–21, and they indicated so unmistakably such rapid and violent alternations, that I supplied our principal relay stations with telephones and with instructions to insert them in circuit whenever they observed indications of disturbances. This happened on March 30–31, during the display of the Aurora Borealis. Mr. Donnithorne, in Llanfair P.G., Anglesea, reports:—"At 2.0 a.m. (Saturday) the telephone receiver was again tried, and then 'twangs' were heard as if a stretched wire had been struck, and a kind of whistling sound. The strength of the earth current was 17·7 milliampères." Mr. Miles, in Lowestoft, reports:—"Noise on 408 (Liverpool-Hamburg) wire seemed like that heard when a fly-wheel is rapidly revolving," and "sounds in telephone appear like heavy carts rumbling in the distance." Mr. Scaife, in Haverfordwest, reports:—"March 31, 2.5 a.m.

Earth currents on all wires; wires completely stopped. . . . Peculiar and weird sounds distinctly perceived, some high-pitched musical notes, others resembling murmur of waves on a distant beach. . . . The musical sounds would very much resemble those emitted by a number of sirens driven at first slowly, then increased until a 'screech' is produced, then again dying away. Duration of each averaged about twenty seconds." These experienced observers, situated at three distant points, and perfectly acquainted with the ordinary inductive disturbances on telephone circuits, simultaneously observed and independently recorded their own impressions of peculiar sounds exerted in telephones by very rapid alternations or pulsations of currents which accompanied or were consequent on sun-spots, earth currents, and the Aurora Borealis.

W. H. PREECE.

G.P.O., April 9.

AURORAL EVENTS ARE HOLISTIC TRANSACTIONS

AURORAL EVENTS EXCEED THE ENVELOP OF SUN AND EARTH REGIONS:

THEY ARE VRIL GENERATED INFLECTIONS OF ENORMOUS UNIVERSAL EXTENT AND SUFFUSION

RECORDS OF TELEGRAPHIC DISTURBANCES ARE EXTANT

TELEGRAPHIC POTENTIALS WERE NON-EXPERIENTIAL ENGRAVINGS

SOME TELEGRAPHIC RECORD ENGRAVINGS CORRESPONDED WITH VISCERO-EIDETIC EPISODES

DURING THE MOMENTS OF THEIR REGISTRATION

VRIL TELEPHONIC SOUNDS EXCEED MEASUREMENTS OF THEIR DETRITAL POTENTIAL

VRIL TELEPHONIC SOUNDS ARE VISCERO-EIDETIC IN CONTENT

VISCERO-EIDETIC CONTENT IS PENETRATING

AND EXCESSIVE IN TRANSMUTATIVE POTENTIAL

AETHERFORCE

ON THE MANAGEMENT OF TELEGRAPHS.

On page 217 of our last volume we published an article on the "Management of Telegraphs," which had reference to an important suit growing out of what was deemed a laxity on the part of the American Telegraph Company in the delivery of a message. That article has attracted considerable attention and has at last elicited a reply from Hon. J. D. Caton, Chief Justice of Illinois, who has had much experience in connection with the management of telegraphs.

The following is Judge Caton's reply to us :—

You say : "The truth is that the present system of telegraphing is just as plain and simple as any of the arts which men practice. There is no more difficulty in writing messages correctly than there is in penning an account or copying a letter properly. If the message is written correctly by the operator at the start it cannot possibly go wrong over the wires. The skill required in telegraphing is of a very ordinary nature —it is a labor analogous to writing with a common pen."

Admitting for the present that, theoretically and in the laboratory, every one of these statements may be true, yet practically on long telegraph lines every one is incorrect, as every practical telegrapher will testify. This you will appreciate by a little reflection upon well-established facts with which you are familiar. The telegraphic alphabet is formed of dots, lines and spaces. If from any cause two or more of these dots are run together a line is made, or, if one is omitted, a space is left and a different letter is formed than the one intended. For instance, the letter *s* consists of three dots. If two of these dots are run together an *s* or an *n* is made, or if one is omitted, we have an *i* or an *e*, and so I might illustrate throughout the alphabet. Now, it is liable to occur and does often happen, that one letter may be substituted for another, which will still make sense in a message but of an entirely different meaning. Hence, I say with the Kentucky Judge, whose ignorance you reprove, but for whom I am inclined to break a lance, that there is no absolute security against mistakes but to repeat the message back. In his defence allow me to say that I understand that charge was founded upon the testimony of a great many of the most experienced and intelligent telegraphers. He should be excused then, for telling the jury that safety requires that the message should be repeated back to guard against all chance of mistakes. And I submit that you were a little hasty and a little harsh when you said : —"This repetition business has always appeared to us like a dodge to extort money on the one hand ; while on the other it seems intended to serve as a screen behind which the company may run to hide itself from the consequences of its own gross neglect." Now, it seems to me that good faith to the public and justice to the telegraph companies, demand the truth on this as on all other subjects. I will therefore state, in as few words as I may, how it is that such errors must inevitably sometimes occur.

You are aware that upon the accurate operations of the relay magnet, and especially that portion of it where the connection is made in the local circuit, everything depends. This connection is effected by two blunt platinum points being brought together by the influence of the magnet, and again separated by the force of an opposing spring. Every time these points are separated a particle of the metal is fused or is burned by the electricity with which it is charged. When a particle of platinum is simply fused it is liable to span the space separating the two points and prevent the circuit from being broken. This would necessarily run two or more dots into a line. When however, the intensity of the current exceeds the fusing point, which is usually the case, the metal is burned, leaving a residuum, which is an insulating substance, and this may, and frequently stance. On a damp day, not only does more or less electricity find its way to the ground at every pole even with the best insulation, but as the humid atmosphere is itself a conductor, from every yard of the wire some portion of the electricity is discharged to the earth, thus forming a ground circuit stronger and stronger as you recede from the main battery. Hence, if the circuit is broken at a distant office, your magnet remains partially charged, and when the circuit is again closed the magnet attains its full strength quicker than if it had been entirely neutral ; hence, the necessity that your adjusting spring be drawn further back when working with a distant office on a damp day than with one near. This could be at least partially remedied by careful adjustment if the loss of electricity were uniform ; but it is not. As the humidity and temperature of the atmosphere are constantly changing so is the amount of electricity conducted to the ground in the mode stated constantly changing, and hence the constant variation of the strength of this ground circuit, and as this controls the strength of the magnet dots may be run into lines or they may be omitted by these instantaneous changes in this inevitable ground circuit.

But there is another practical difficulty which you will readily appreciate as its cause must be familiar to you : That is the electrical currents which are constantly coursing their way through the atmosphere. These act through the wire and operate upon the magnets precisely the same as the electricity, generated in the battery. Ordinarily, these are so slight as to occasion no practical inconvenience to the telegrapher ; but sometimes they are so strong and constant as to work the telegraph wire without any battery. These atmospheric currents, when flowing in the same direction as the battery currents, increase it, or if in an opposite direction neutralize it in proportion to their strength, again rendering it possible to change one letter to another as above described.

I have thus pointed out some of the most prominent and patent difficulties with which the telegrapher has to contend in order to avoid errors. They are all well established facts attested to by the experience of every practical telegrapher. Necessarily they must sometimes lead to mistakes which the highest possible care cannot avoid, and which can only be detected by repeating the message back. This with ordinary care must detect the mistake ; for it is hardly possible that the same interruption should occur from any of these causes to produce the identical error in the repetition.

These are not theoretical difficulties—they are practical. If all operators do not understand the cause, all experience the difficulties. With so much to contend with it is indeed wonderful that so few mistakes are made, and I think the telegraph companies are entitled to the highest credit for that degree of perfection to which they have trained their numerous operators.

You were in error then when you said that "this repetition business" is a dodge to extort money or excuse gross neglect. The truth is it is necessary to insure accuracy, and you can do the public no higher service than to impress this fact upon them. But this liability to mistake is slight and very few mistakes are made considering the number of messages sent. Yet it does exist and should be guarded against in all important messages.

J. D. CATON.

Ottawa, Ill., Sept. 11, 1862.

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